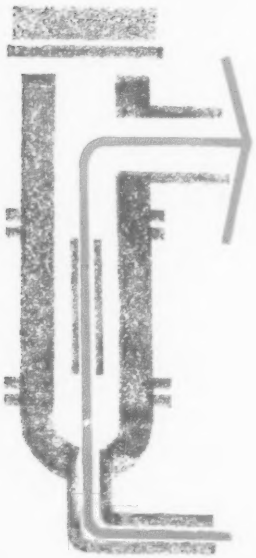
OIL, GAS AND PETROCHEMICAL PROCESSING

Petroleum Refiner

FEBRUARY
1960



What You Need to Design

THERMOSIPHON REBOILERS

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BETTER ACCESS

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NEW METHOD

Cut Costs for Tank Foundations 165

For a "Quick Look" at this issue, turn the page . . .

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This small piston-like valve, only moving part in the Yarway Impulse Trap, continually tests for condensate, discharges it as soon as it forms.
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Volume 39, No. 2 February 1960

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Petroleum Refiner

OIL, GAS AND PETROCHEMICAL PROCESSING

A Gulf Publishing Company Publication

A Quick Look at This Issue

These handy digests permit checking the articles you want to read first. ☑

☐ **How to Design Thermosiphon Reboilers . . .** Here is a rational, systematic method for designing vertical thermosiphon reboilers. It is based on semi-empirical correlations of experimental data, and permits you to make more reliable estimates of reboiler performance. The method is broken down into a step-by-step procedure with sample problems to show you how the method works. Turn now to **Page 105.**

☐ **Find Physical Properties of Ethylene . . .** Here are useful physical data for liquid and gaseous ethylene. You'll want to clip this one for your notebook so turn to **Page 124.**

☐ **Get K-Values by Chromatography . . .** and activity coefficients plus other thermodynamic data. This article shows how GLPC data can yield thermodynamic information which compares favorably with static experimental data. See **Page 125.**

☐ **Estimate Inert Gas Plants Quickly . . .** by using these charts. Here you can quickly find the total direct installed costs for complete inert gas plants up to 100,000 scfh. Be sure you turn to **Page 129.**

☐ **Automation Today, Part 18 . . .** Previous discussions in this series concerned open loop systems and sine wave frequency responses. Now the authors tackle closed loop control systems and introduce the concept of complex frequencies. See how they apply the Bode and Nyquist diagrams to these types of systems. **Page 132.**

☐ **How to Design Heat Exchanger Piping . . .** Good exchanger piping arrangement is essential for access, ease of maintenance and good operation. Follow these details and you'll be sure to get good exchanger piping arrangement. Turn to **Page 137.**

Please Turn Page ➔

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is easier with a LJUNGSTROM® AIR PREHEATER

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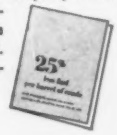

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A Quick Look at This Issue . . .

☐ **How to Estimate Chemical Selling Price . . .** is an empirical correlation based on molecular weight. For the approximate selling price of those chemicals under development, turn to **Page 153.**

☐ **Coker Can Handle High Carbon Stock . . .** Unlike most delayed cokers which process lighter feed stocks, American Oil's coker charges feed directly from the bottom of a combination crude tower. You'll find an appraisal of that coker's operation by turning to **Page 155.**

☐ **Why Compressor Thrust Bearings Fail . . .** To insure a reliable repair job and avoid further problems, a detailed investigation to find a definite cause for the failure is required. These trouble-shooting clues to bearing failures and typical thrust load calculations will help you find and eliminate the cause of most failures. For details on the procedures to follow, turn to **Page 159.**

☐ **Cut Foundation Costs for New Tanks . . .** For a new storage tank, a piled foundation can often cost as much as the tank itself. But here's a method which gets away from piling and reduces the cost of storage facilities. The author also discusses alternate methods which can give less expensive storage construction. Turn now to **Page 165.**

☐ **Employe Health—A Management Function . . .** Keeping employes healthy as well as happy is essential to industry. However, management must realize that curing mental and physical ailments is not enough —a preventive approach is also necessary. Many of the problems that arise because of mental conflicts or maladjustments can be solved or at least alleviated by proper human understanding. For this full story, be sure to turn now to **Page 185.**

☐ **How Professional Is Your Management? . . .** Does your management realize its obligations to its technical employes? Does your management encourage professionalism? A "no" answer to either of these is good news to Walter Reuther who says that organizing engineers and scientists is the "most essential organizing task facing the trade union movement." You'll want to be sure to read this timely and informative article where you get the chance to rate your management. Turn now to **Page 190.**

☐ **How Well Do You Supervise? . . .** A good supervisor should know the limits of his authority and responsibility. But more important than the amount of his responsibility is how well he performs it—more important than his authority is his ability to apply it. You'll derive a great deal of benefit from this article, so be sure you turn to **Page 194.**

Labor Estimating Help

Gulf Publishing Company's new Labor Estimating Library will enable you to slice estimating time to a minimum, while maintaining maximum estimating accuracy.

Presently, there are two manuals in the library: Estimator's Piping Man-hour Manual (Price $7.50 a copy) and Estimator's Electrical Man-hour Manual (Price $10 a copy). Both are by John S. Page and Jim G. Nation.

The manuals do not deal with the technical aspects of electricity or piping. Their single and important purpose is to set forth a standardized method of estimating electrical or piping installation in man-hours.

The scores of man-hour tables in each manual contain literally thousands of easy-to-use listings. These listings are valuable guides to estimating man-hours in every phase of electrical or piping installation and fabrication. They are the result of hundreds of time-and-method studies, coupled with actual labor costs of operation, on numerous projects.

Why a Labor Estimating Library? Because, there are two very important things to consider when thinking in terms of labor dollars for an estimate. They are productivity efficiency coupled with production elements.

The authors, estimators by profession, have found after much comparison on many projects that production efficiency can be classified into five categories. Production elements can be grouped into six different listings.

Using this experience, they have devised an accurate and convenient method of estimating direct labor for complete electrical installation for any given system. By means of the manuals, the user has a dependable method of obtaining a production efficiency percentage by applying all known local conditions and variables, plus a method of obtaining a complete direct labor rate for the craft or crafts involved.

With these manuals you'll know how to arrive at a composite rate using productivity efficiency and production elements. With the composite rate, man-hour estimating can be applied with equal validity to any electrical or piping installation and fabrication job, in any location.

Another manual, the Estimator's General Construction Man-hour Manual will be published shortly.

Copies of the Estimator's Piping Man-hour Manual and Estimator's Electrical Man-hour Manual are available from Gulf Publishing Company, P. O. Box 2608, Houston 1, Texas.

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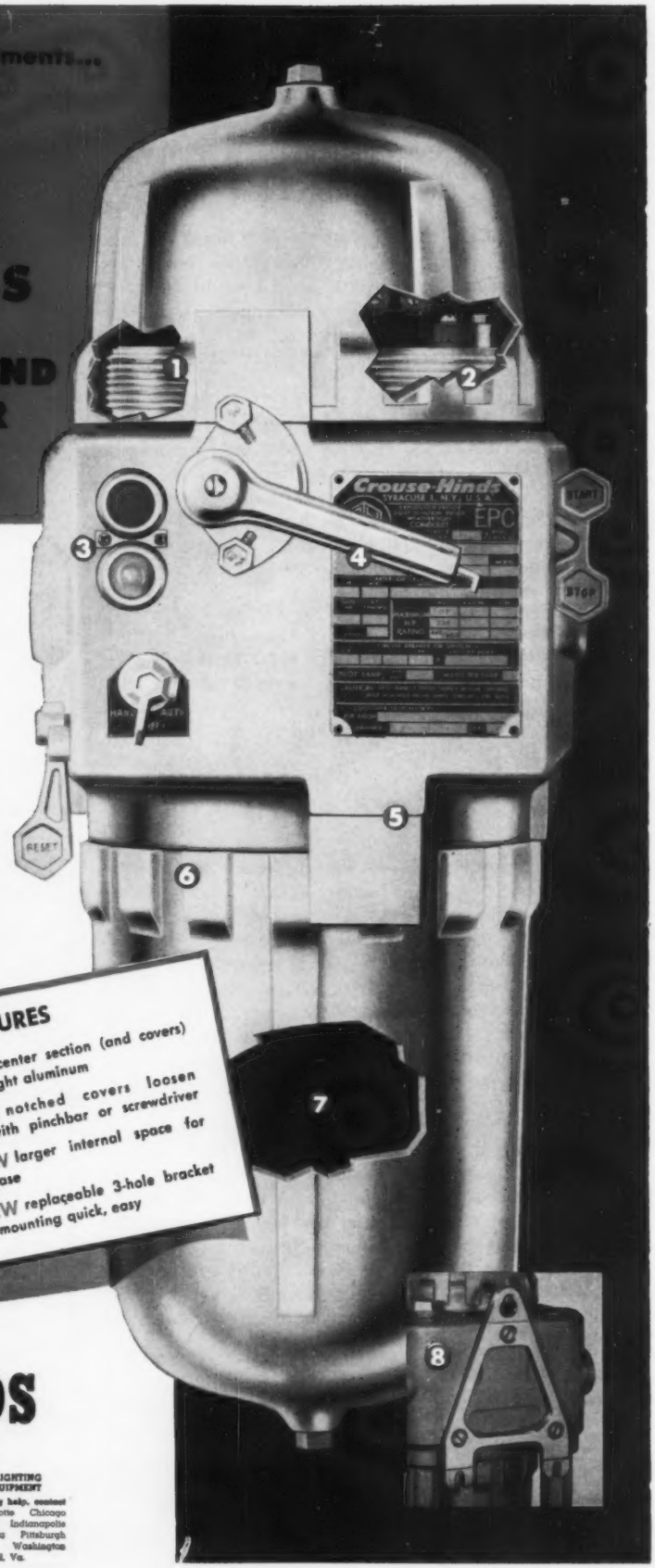

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PIPE LINE INDUSTRY and The PIPE LINE CATALOG for the oil and gas pipe line industry.

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March Stars Ethylene

PR's MARCH ISSUE deals particularly with the star of the petrochemical industry, ethylene, which has enjoyed remarkable growth and which has had such a potent effect on the entire industry. In this Special Report you will find:

- A complete summary of ethylene uses, production and consumption patterns and manufacturing technology;
- Seven of the most important cracking techniques in detail along with some new and unique pyrolysis methods;
- Analyses of major purification and separation methods, and how cracking stock, cracking method, separation and purification tie together;
- How choice of feedstock affects the complexity and capital investment requirements for ethylene plants; and
- How yields and by-products enter into this economic picture and what role their use and/or elimination play in plant design.

Then there's another plus: The most comprehensive bibliography on ethylene collected since the early 30s. This gives titles of articles which will be most helpful if you're skimming through with definite subjects in mind.

That's PETROLEUM REFINER's bonus for March!

Two in a Row

PETROLEUM REFINER authors John Hodson and C. J. Huang have received the "Best Applied Publications Award" given annually by AIChE's South Texas Section. The winning article was "Perforated Plates Designed This Way," from the February 1958 issue and both authors received plaques at the Section's annual technical meeting in Galveston October 30. This is the second successive year that PETROLEUM REFINER has shared the award, authors Louis Bullington and Irving Leibson having run away with the honors the previous year. Needless to say we are proud of this noteworthy record.

This Is THE One

WITH PR's annual Maintenance Issue such recent history it is quite appropriate to quote a pertinent statement we received recently from the general foreman of a petrochemical plant in South Texas: "If I had to use only one magazine this (PETROLEUM REFINER) would be the one of all the rest," he wrote.

Now, if we could just get that evaluation before the eyes of maintenance men everywhere, maybe it would help them to accept and act upon some of the things our Circulation people have been telling them. Actually, PETROLEUM REFINER is far, far ahead of other magazines in its field in the important matter of maintenance.

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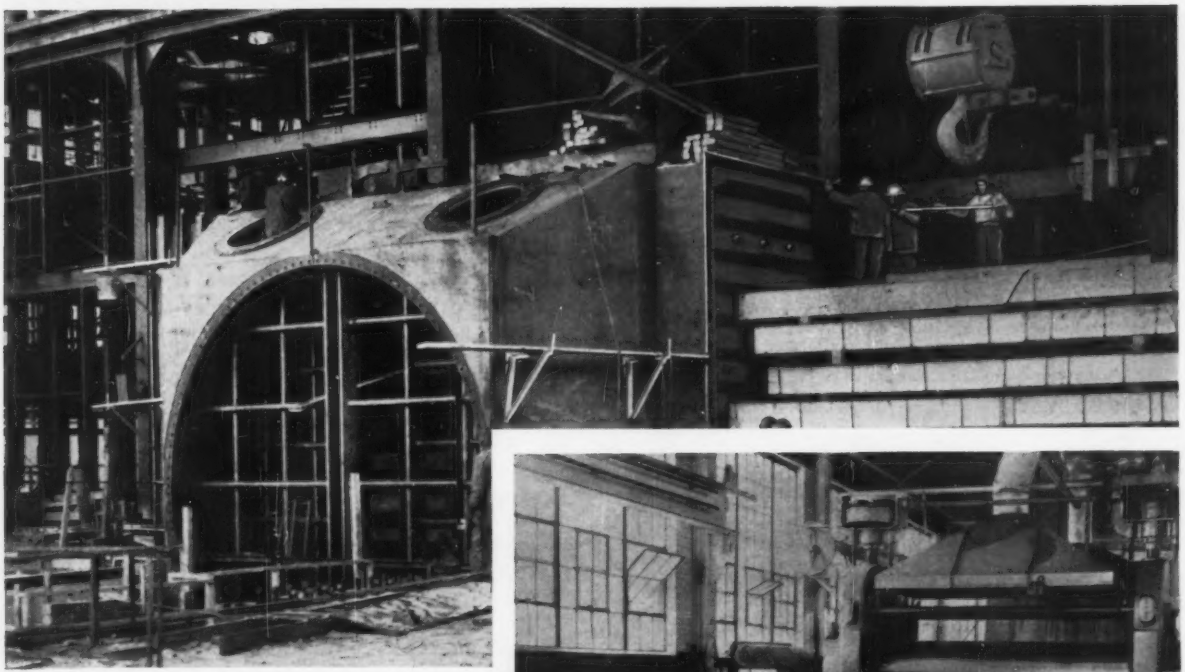

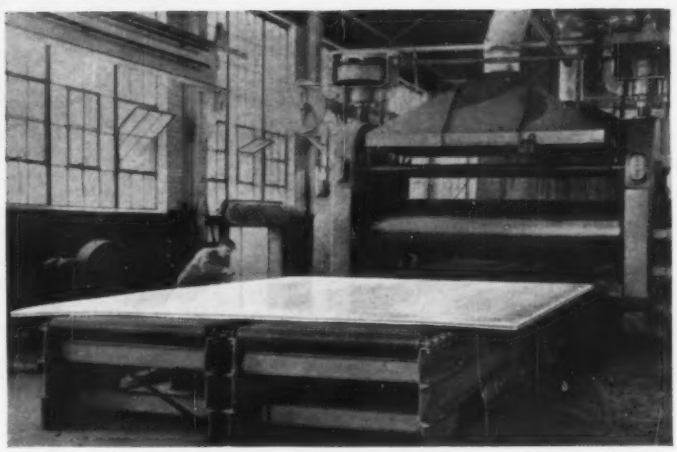

TOP: View of the new Clinch River Plant of Appalachian Power Co., at Carbo, Va. **ABOVE:** Tubing one of the two huge Allis-Chalmers surface condensers. The 26' x 15' openings in the shell use two Anaconda Leaded Muntz Metal-274 plates, each 156" x 189" x 1½" and weighing 13,700 lb. American Brass furnished the eight plates required, as well as the Arsenical Admiralty-439 tubes for the unit above — 19,100 lengths, ⅞" x .049" x 30'. **RIGHT:** The big rolling mill at American Brass Company's Detroit Division which produced the plates.

THE unusually large plates required for the tube sheets at Clinch River Plant are standard items of The American Brass Company, which produces plates of copper and a number of copper alloys in rectangular sizes up to 156 inches in width and 15,000 pounds in weight. The maximum standard limits for circles are 160 inches in diameter and 11,000 pounds in weight. Half circles can be produced up to 13,000 pounds in weight.

ROLLED PLATES SUPERIOR. Anaconda rolled plates are commercially flat, accurate in dimensions, and free from surface imperfections and porosity often prevalent in cast plates.

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Quick Look at Industry...

Sohio, Leonard Call off Merger . . .

Sohio gives up plans for merging with Leonard Refineries—says time required to get final decree in Justice Dept.'s injunction suit left no other choice. Even if merger had received green light from District Court, Justice Dept. appeal could result in years of litigation.

Leonard markets gasoline exclusively in Michigan—Sohio just in Ohio. Small quantities of other products marketed under other brand names by Sohio in Michigan.

Last October, Justice Dept. also halted Texaco-Superior merger by threatening injunction. Like Sohio, Texaco and Superior felt at best, would mean several years of litigation.

First U.S. Giammarco-Vetrocoke Process Plant Finished . . .

First U.S. installation of Giammarco-Vetrocoke process for acid gas removal now complete near Fort Stockton, Texas. Built for Transwestern Pipeline, plant hasn't started up yet—Transwestern's pipe line not finished from Texas to California. Plant will reduce carbon dioxide from 28% to 2% in 180 MMcf daily (at 1050 psig). Will also free gas of 0.2% hydrogen sulfide (more on Page 177).

More Computers for Process Control . . .

Digital computers now used for on-line control at Monsanto's Luling, La., ammonia plant and B. F. Goodrich's vinyl chloride monomer unit at Calvert City, Ky. If all goes as expected, plants will operate near optimum most of the time. Probable result: more computer installations.

Four-Way Effort to Release Tar Sand . . .

Four companies, Imperial Oil, Cities Service, Richfield, and Royalite join forces in effort to release liquid hydrocarbons from Athabasca tar sands in northern Alberta. Cities Service Athabasca, subsidiary of Cities Service will operate the project—Imperial, Cities Service and Richfield each own 30% with Royalite holding 10%.

Estimate sands at or near the surface hold 40 billion barrels recoverable oil (PETROLEUM REFINER, Jan. 1959, p. 199). For years individual companies have been researching commercially feasible extraction methods. Cities Service built $3.5 million pilot plant at Mildred Lake, Alberta two years ago. Plant contains 3,000-bpd distillation unit, separation equipment, collateral facilities and mining "wheel" (more on Page 213).

Panning the Building Scene . . .

Conoco to build $1 million cyclohexane plant at Ponca City refinery. Annual capacity pegged at 20 million gallons—completion set for Sept. '60 . . . California Standard Western Operations planning 13,000-bpd FCC and alky unit plus hydrogenation and isomerization units at Barber's Point, Honolulu plant—will be completed by mid-'62 and will double company's original $33 million investment . . . New cyclohexane plant now on stream at Gulf Oil's Pt. Arthur refinery . . .

DX Sunray to build $1 million benzene unit at Tulsa plant . . . British American hiking Calgary plant from 7,500 to 10,000 bpd.

Methyl Lead Compound in the Spotlight . . .

Tetramethyllead getting recent play by Mobil Oil. Company claims TML better for upgrading octanes in gasolines having high aromatic content. Since aromatics are big part of present day fuels, look for TML to get close study from oil companies and additive makers.

Another Finger in the Methane Pie . . .

Royal Dutch Shell Group buys 40% interest in Constock International Methane—leaves 40% for Conoco and 20% for Union Stock Yard and Transit, Chicago. Previously Conoco and Union each had 50%. Deal did not include all Constock assets, tankship "Methane Pioneer," liquifaction facilities at Lake Charles, inventories of balsa wood or other miscellaneous equipment. "Methane Pioneer" has six successful voyages to England delivering 2,000-ton cargoes of liquid methane. Later name of Constock will change to Conch International Methane, Ltd.

And Speaking of Foreign Joinings . . .

Continental Carbon, Amarillo, and Columbian Carbon, New York, forming strong ties in Europe. Columbia bought interest in Continental's new carbon black plant in Rotterdam—plant will operate as Continental-Columbia Carbon (Nederland) N.V. Then Continental bought interest in Columbia's carbon black plant near Milan, Italy. Plant will operate as Columbian Continental Europa, S.p.A. Continental Carbon owned by Conoco, Shamrock Oil and Gas and Witco Chemical.

Mobil International buys interest in Barbados Union Oil, independent refiner serving Barbados Island in West Indes.

Quick Look Around the World . . .

Dow to start marketing fluid to replace antifreeze, water and rust inhibitors in auto cooling systems—provides sealed cooling for one year . . . Maruzen Oil signs agreement with Mobil to export 1,500 bpd of naphtha to U.S. over 6-month period . . . Saudi Arabia still trying to persuade foreign companies to help create petrochemical industry in that country . . . NLRB sets Feb. 25 as bargaining agent election day at Esso's Bayway plant—1,500 will vote for OCAW, IPWU, Teamsters, Operating Enginers, or no union . . . Salaried lab technicians at Esso's Baton Rouge plant vote overwhelmingly for International Industrial Workers Assn. rather than no union.

Focusing on the Octane Picture . . .

Premium held steady last month at 99.3 F-1 octane, but regular slipped 0.1 for an average of 92.3F-1.

Rubber Goes Underwater . . .

New rubber coating permits vessels to travel underwater faster without increase in power—uses same principle which allows porpoises to swim so fast. Will probably increase submarine speeds to 70 mph in near future—over 200 mph later. Now researching same principle for missiles, rockets, planes and liquids flowing thru pipes. Would mean bigger rubber market.

What to Expect from Steel Prices . . .

During first half 1960 selected steel prices will rise about 3.9% over Nov., '59, says economic consulting firm. No across-the-board hikes, but look for 5% price rise in structural steel shapes—being high volume item this is logical choice. Since 1947-1949 structural steel shapes have risen nearly 100% as opposed 87% for all other finished steel prices.

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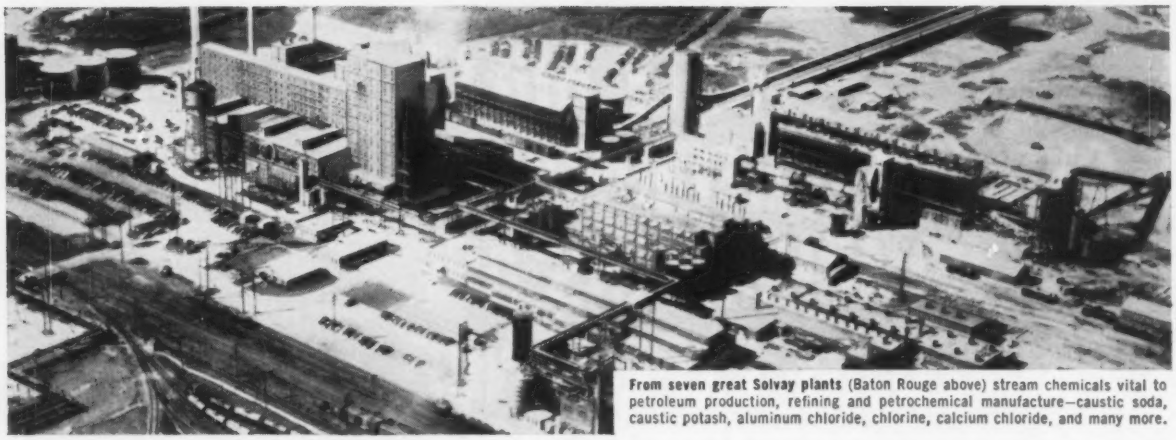

From seven great Solvay plants (Baton Rouge above) stream chemicals vital to petroleum production, refining and petrochemical manufacture—caustic soda, caustic potash, aluminum chloride, chlorine, calcium chloride, and many more.

How Solvay Chemicals Serve the Petroleum Industry

Increasing demands for a diversity of chemicals satisfied by America's pioneer producer of alkalies

From the primitive Drake Well of 1859 to the complex "cat crackers" and petrochemical plants of today, oil's appetite for chemicals has grown enormously—both in the number and variety of products consumed. Closely paralleling this need, the Solvay® line of alkalies and related chemicals has been continually expanding for almost eighty years. Many of Solvay's fourteen branch offices and seven manufacturing plants are strategically near oil production and refining centers. Fast dependable supply is further assured by over two hundred local stockpoints and a nationwide network of responsible distributors. Technical service is available through skilled representatives backed by years of experience in the handling and uses of Solvay chemicals in many industries.

Major Uses of Solvay Chemicals in Petroleum

Potassium carbonate— To remove carbon dioxide and hydrogen sulfide from process gases.

Aluminum chloride— To produce detergent intermediates and other alkylates.
For isomerization.
For polymerization.
For manufacturing ethyl chloride used in tetraethyl lead.

Caustic soda— For treating applications —i.e., the removal of hydrogen sulfide and lighter mercaptans.
For doctor sweetening.
To neutralize acid treated oils.
To neutralize acidic product streams.
For electrical desalters—to control pH of their precipitated brine solution.

Caustic potash— For treating applications—i.e., the extraction of mercaptan from light petroleum fractions. Its higher reactivity and lower viscosity enables faster, more complete separation.
For desulfurizing petroleum products because of its high reactivity.
For Dualayer® Distillate Process.

Calcium chloride— A desiccant for drying LPG streams.
To recover oil from waste. Its strong electrolytic action breaks oil emulsion.

Carbon tetrachloride— For solvent extraction processes.

Chloroform — For solvent extraction processes.

Chlorine— For water treating.
For manufacturing hypochlorite used in treating gasoline.
For producing petrochemicals.

Soda ash— For water treating.
To liberate DEA from heat stable salts.

Sodium nitrite— To combat corrosion.
Used with nitrates as a heat transfer medium.

Vinyl chloride monomer — To produce plastics and surface coatings.

Chromium chemicals— To prevent water-side corrosion.
To prevent corrosion in recirculating water systems of cooling towers.

Allied Chemical

SOLVAY PROCESS DIVISION
61 Broadway, New York 6, N. Y.

Send export inquiries to Allied Chemical International, 40 Rector St., N. Y. 6.

MAIL TO SOLVAY if you want further information on these products or applications. Describe below or accompany with a letter.

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The Standpoint of 'Do It Yourself'

THE YEAR 1960 is still young; yet, the old unsolved problems have already reared their heads—imports, strikes, expense accounts, etc. All these things are problems that the government has something to say about—more each year. Does it have to be this way?

Take expense accounts, for example. The government is taking a closer look at these this year. It's understandable that one citizen who works for a company without a fishing yacht resents the fact that his neighbor uses a company yacht for family recreation on the weekends. And it's also understandable why the government is under pressure to see that such advantages are for business purposes and not just subtle ways of rewarding tax-eaten employes.

But shouldn't the company with the yacht be the most concerned? Should not this company regulate its affairs so that it is obvious that the money it spends is for hard-headed business reasons and not for flirtations with current tax laws? When laws are not obeyed, can company rules be far behind? And when government rules are not obeyed, can more regulation be far behind?

Give Up Like Cynics? So there is not only the possibility but the necessity for a company and industry to regulate itself. The problems of the oil industry can be pretty knotty and require a lot of creativity for their solutions. But then we have a lot of creative people and we are very proud of our technical achievements. Why give up like the cynics on problems requiring self-regulation?

It's not hard to find businesses that have made self regulation work. The magazine business, for example, had the very real problem of being sure that a paid subscriber was indeed one who had voluntarily paid money to subscribe to a magazine. To impress potential advertisers with their readership, some circulation managers had fictitious names on their circulation lists and some used devious ways to get a reader to pass money for a subscription.

The upshot was the formation of the Audit Bureau of Circulation, a cooperative association of advertisers, advertising agencies and publishers, for the verification of the circulations of newspapers and periodicals. ABC lays down rules as to who is a paid subscriber and how he may be wooed. Further, ABC sends auditors to publishing houses to check their circulation methods and to make audited reports.

It could have been different. The clean publishers could have run to the government for help. The advertisers could have demanded regulation by the government. But ABC is evidence that business can clean its own house and police its ranks.

How does the government feel about self-regulation? You can get a good idea from a recent speech by Earl W. Kintner, Chairman of the Federal Trade Commission. Said Kintner, "I think it is tremendously important that we realize that self-discipline by businessmen can deteriorate—and that delay hastens decay. The capacity of business to police itself can be sapped by indifference, by ignorance, by avarice. It also can be undermined by the surrender of moral responsibilities to government—the demanding of new laws to fill the vacated bastions of self-reliance.

For the Errant Few. "Far better that governmental policing be accorded its proper role of restraining the errant few. Give it authority and strength to strike fast and hard at those who refuse to police themselves.

"Let us accept and put our faith in the political and economic system that developed this great nation of ours. Let us exalt in the privilege of living and working under a capitalistic free enterprise system—a system whose energies derive from the freedom and capacity of individual citizens and whose necessary restraints are imposed by government. One is the engine; the other the brakes. We need both. And please, God, may we never transpose these functions."

With self-discipline at a cross roads, we need to ask ourselves once again about our serious problems. Have we given the imports problem all the self-regulation it is due? Are we laying the proper groundwork for our labor relations, so we won't have to call in government to help settle strikes? In short, have we looked at our problems from the standpoint of "do-it-yourself"?

These, Too, Are Monopolies

PROBABLY ONE of the most disturbing points of the recent steel strike was the talk of the need

HOW EMPHASIS ON COMMUNICATIONS SERVES HOUDRY CUSTOMERS

When you contract for technical service, or seek information on Houdry processes, catalysts or chemicals, a unique business communications system is immediately put at your disposal.

The effect is that your initial contact with any one section of Houdry's technical sales and service group also makes available the knowledge and experience of the *whole* group.

For instance, if you are primarily checking properties, availability, etc., of a catalyst, but would also like to check out some ideas for process changes, you can get the additional service promptly through the closely knit internal communications channels of Houdry's technical sales and service organization.

You'll find everything Houdry offers you—processes, engineering, research, catalysts and chemicals—as modern and straightforward as Houdry's advanced service ideas. Check into the advantages of doing business with Houdry. You will see why—when the question is catalysis . . . the answer is Houdry Process Corporation.

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PROCESS CORPORATION
1528 Walnut Street, Philadelphia 2, Pa.
*Houdry means Progress...through Catalysis

for legislation which would give Congress a voice in bringing about a compulsory settlement. Few have any doubts that had the strike been resumed following the back-to-work edict of the Taft-Hartley Act, this type of legislation would have been forthcoming with haste. Congress was primed for it!

Of course, this is not to say that some legislation would not have been needed. Just before President Eisenhower invoked the Taft-Hartley Act to send workers back to work for 80 days things were starting to get tight in this country. Auto assembly lines were closing down and some appliance manufacturers were beginning to lay off many production workers. On top of that, it wouldn't have taken long for the effects to have been felt by industries which depend indirectly on steel. For instance, tire manufacturers most certainly would have felt the pinch without a new car market—and eventually this would have spread to the rubber manufacturers. Thus it is quite evident that when the dispute of a single industry threatens to bring a nation as mighty as America to its knees, something must be done.

Get to the Cause. However, amid the many cries of "do something before it's too late," it is both surprising and distressing that all of the demands were for some form of compulsory arbitration. None will deny that this certainly would have been the quick way—and probably the easiest way. But is that what we really want? To have Uncle Sam step in and tell both sides that they have lost their free bargaining rights from now on?

No—certainly not. For this type of solution would be like our medical industry devoting all of its research to curing illnesses and completely ignoring the causes. By the same token, any legislation which would put management-union negotiations completely under the government's thumb is merely attacking the results of a situation and completely ignoring the one thing that is causing it. And the cause in this case, of course, is the Union Steel Workers' advantage of conducting industry-wide bargaining—in short, the union monopoly.

You'll no doubt still hear the parroted cries that individual unions are not powerful enough to hold their own at the bargaining table, and thus they must compete on an industry-wide basis. This is pure unadulterated hogwash—and for those who don't think so let them take a look at the oil industry, which does not have industry-wide bargaining. This is not because the unions would not like it, but rather because the oil industry realizes that different plants and different working conditions require different rules.

Facing the Facts. In refining and petrochemical plants, an individual local union bargains with the individual plant management. Sometimes the issues are settled quickly and amicably, while at other times the struggle stretches out for a period of months and is marked by bad feelings on both sides.

In spite of this, however, not one local has been forced into submission, nor has one been bankrupted by an oil company. One refinery, Amoco's Texas City plant, was struck for 190 days but an agreement was finally reached. It is only reasonable to believe that if it can be done in the petroleum industry it can be done in steel. The union should not have—does not deserve—industry-wide bargaining privileges.

But if perhaps Congress should still find the need for some legislation, we sincerely hope that it will be directed to the heart of the situation—to eliminating the cause rather than altering the results. For sooner or later we are going to have to pull our heads out of the sand and face up to the fact that unions are monopolies, too.

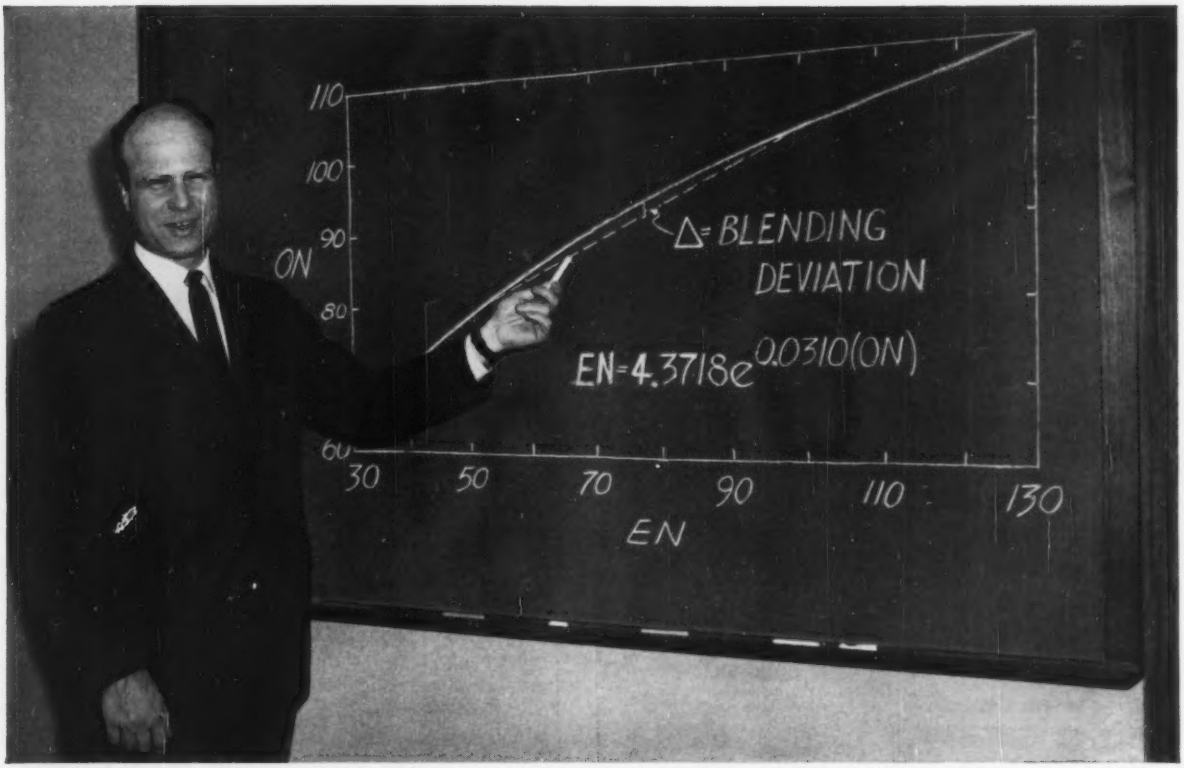
Many members of Congress already realize this, and if enough of them can bring themselves to putting the good of the country ahead of their political ambitions, we can get the legislation needed to break up these union monopolies. This should certainly eliminate further industry-wide strikes which threaten to cripple this nation. And after all, that should be the prime interest of those with delegated governmental authority.

Enough Is Too Much

A RECENT ANNOUNCEMENT that India is continuing to import fertilizers and nitrogen food chemicals using U.S. foreign aid funds should have been encouraging—encouraging because it would indicate that this food-short country would at least try to become self sufficient in feeding its hungry multitudes. However, this announcement brought about more of a feeling of disgust.

This is because on further reading and detailed study, it reveals some money shuffling far from desirable. It seems that India, using United States aid funds will purchase urea and other nitrogen fertilizers from France. This helps French petrochemical manufacturers but doesn't do much for U.S. producers of these same products. (Except, of course, it does continue to add to their tax burden to support U.S. foreign aid.) Payment of U.S. funds into the rupee account will be deducted from the franc account, all this under PL 480. In addition to this, India also plans to buy 100,000 tons of ammonium sulfate and 120,000 tons of urea and other fertilizers from West Germany and other European countries.

If foreign aid is essential to underdeveloped countries, such as India, and we disclaim anything near complete knowledge on this need, surely it isn't asking too much for them to take this foreign aid in kind. U.S. firms at least should be permitted to furnish the fertilizer and nitrogen chemicals. This might not help our budget problems, but at least we would know from where the aid was coming and cut out the effect of double taxation. Looks like we're paying Peter to rob us and both Peter and Paul are coming out on the long end of the deal.



Dr. W. C. Healy, Jr., who devised the new scale for averaging octane numbers, demonstrates an EN conversion curve.

Ethyl Research develops new Octane Blending Scale

FOR MANY YEARS, refiners have been plagued by the fact that octane numbers do not blend by volume. The volumetric average of component octane numbers is usually higher or lower than the octane number of the corresponding blend of the components. This is commonly referred to as a blending bonus (or deficit).

Numerous schemes have been developed to calculate octane quality of finished blends. Unfortunately, few methods have universal application or a simple mathematical approach to solution.

A further disadvantage exists since many of the current blending computation schemes are basically non-linear, and thus have only indirect application in linear programming problems.

New Scale Based on Exponential Function

It has been observed in a review of countless gasoline blending studies that blending bonus (or deficit) tends to vary with the octane differences of the components. To be more specific, in multicomponent refinery blends, the blending bonus is often almost proportional to the average squared octane difference between components. As a result of the discovery of this relationship, the EN scale was developed.

The scale has the following form:

$$EN = a + be^{2k(ON)}$$

where:

EN = converted octane number

a = arbitrary constant

b = arbitrary constant

e = natural logarithm base

k = exponential constant determined for each refinery application.

ON = octane number.

A curve showing this relationship for a specific refinery is demonstrated in the illustration above.

How to Determine the Exponential Constant "k"

The exponential constant k may be determined very simply for a particular refinery from a group of typical gasoline blends. *Blending deviation* (observed blend octane number minus volumetric average of component octane numbers) plotted versus the *volumetric average of the squared component octane numbers minus the square of the volumetric-average octane number* $\left[\overline{ON^2}-(\overline{ON})^2\right]$. The numerical value of k is the slope of a line through the plotted points and the origin. In order that different TEL levels be represented in determining k, the plot should encompass a range—say 0.5 and 3.0 ml/gal.

To completely define the new blending scale, values must be assigned to "a" and "b". The choice is completely arbitrary and is governed by convenience. For example, values may be chosen

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so EN is equal to 100 when ON equals 100; or the EN scale may be made to match the ON scale at two points, for example 80 and 100. It is usual for b to have the same sign as k so that ENs increase when ONs increase.

How Accurate is the Scale?

In order to check the accuracy of the scale and illustrate its efficiency, standard errors are compared for four systems of determining final blend octanes.

1. Volumetric average of *component ONs*.

2. *Octane blending values* by least squares method and volumetric average of values so determined.

3. Volumetric average of *component ENs* and conversion of this average to ON.

4. *EN blending values* by least squares method, volumetric average of values so determined, and conversion of this average to ON.

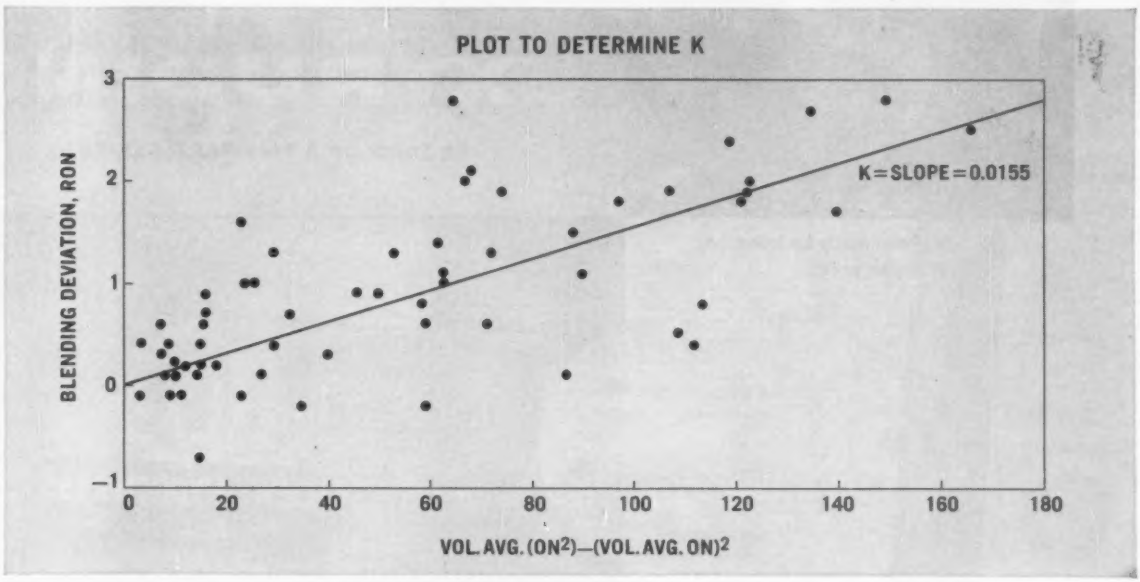
The table shows a comparison of standard error in RON for the four systems using 30 blends of 11 components. It is interesting to note that simply using component ENs compares in accuracy with the volumetric average using octane blending values by least squares. Accuracy is significantly improved when EN blending values determined by least squares are averaged volumetrically.

SUMMARY

Octane blending may be linearized by changing octane numbers to ENs using Ethyl's exponential scale. The method is equally usable with Research and Motor octanes and accuracy is improved over other known systems. It is directly applicable in linear programming.

COMPARISON OF STANDARD ERROR, RON

	Predicting Method			
TEL, ml/gal	Component ON	Octane Blending Values	Component EN	EN Blending Values
0.5	1.63	0.71	0.63	0.43
3.0	0.87	0.56	0.53	0.44



How Ethyl Research can help you

Mathematical Analysts in Ethyl's Refinery Technology Division will be glad to show you how the EN scale can be applied to your gasoline blending.

For an appointment with one of these specialists, see your Ethyl Representative.

Your Ethyl Representative also can supply you with copies of the paper, "Two Approximation Problems in Linear Programming of Gasoline Blending," presented at the computer conference of the Western Petroleum Refiners Association held in Tulsa, Oklahoma last December.

ETHYL ANTIKNOCK COMPOUND — ETHYL CORPORATION

ETHYL CORPORATION
New York 17, N. Y.

Ethyl Corporation of Canada Limited, Toronto
Ethyl USA (Export) New York 17, N. Y.

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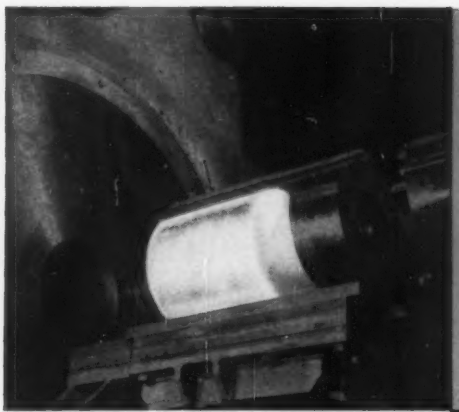
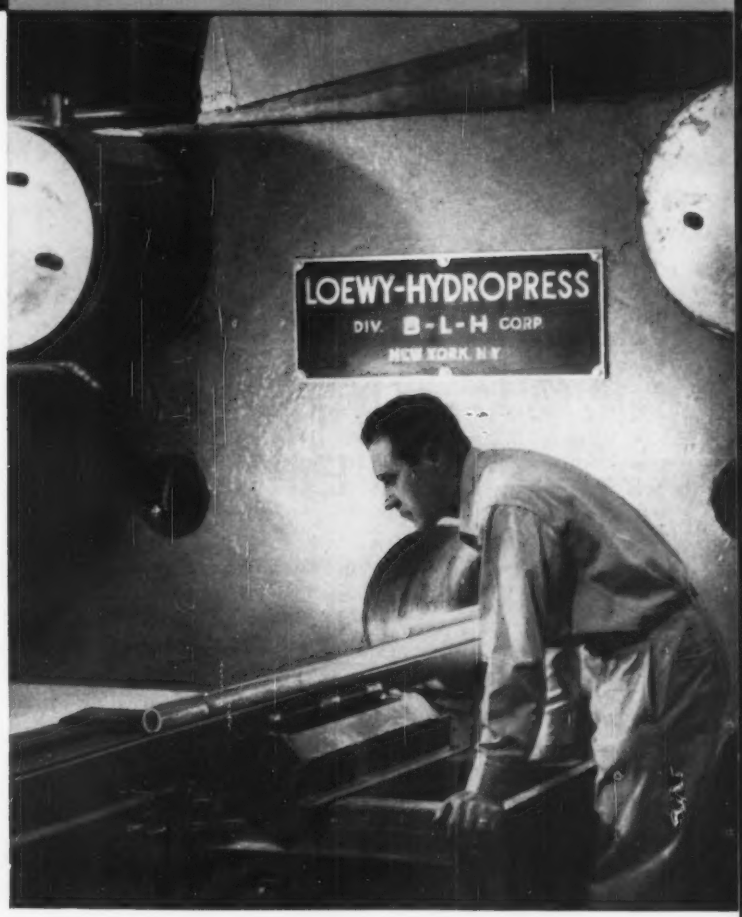
How lasting quality is Heat Exchanger



2 EXTRUDING

(SECOND OF A FIVE-PART SERIES)

Heated billet ready for insertion into extrusion press.



Billet emerges from extrusion press as a heavy-walled tube, or shell.

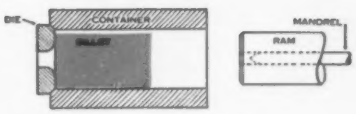
built into Phelps Dodge and Condenser Tubes...

Phelps Dodge heat exchanger and condenser tubes are formed from billets by the hot-forged extrusion process, a method that produces sturdy, seamless tubes with long service life, finest properties and precise dimensions.

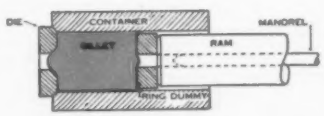
The metal billet, before being placed within the container of the extrusion press, is first heated in a controlled atmosphere to a temperature predetermined for each specific alloy. The subsequent forging (upsetting) and extruding operations are combined in a simultaneous operation.

The billet is forged by a compression system using several million pounds of hydraulic pressure. This operation refines the grain and achieves maximum densification of the billet. Finally, a highly polished steel mandrel is used to pierce the billet, thus forcing extrusion of the metal over and around the mandrel and through a steel die into the form of a heavy wall tube.

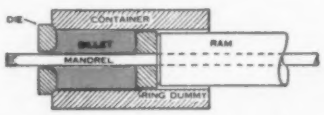
Throughout the entire tube fabricating operation—from raw materials to finished product—quality is the keynote. That's why Phelps Dodge tubes are preferred by those who demand the finest . . . the manufacturers and users of heat exchangers and condensers.



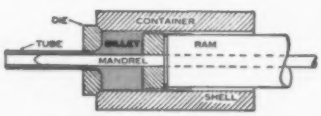
Billet is placed within container for forging operation.



Heated billet is forged within container through action of the ram pressing on the ring dummy-block.



Steel mandrel pierces billet just before extrusion takes place.



Hydraulic pressure exerted on ram and ring dummy-block causes metal to flow over mandrel and through die.

PHELPS DODGE COPPER PRODUCTS CORPORATION

First for Lasting Quality—from Mine to Market!

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Here's a vertical turbine with

TERRY SOLID WHEEL

and all its advantages

When it comes to judging a turbine's ability to deliver in vertical service, ratings tell only half the story. It's the Terry construction refinements that give you assurance of long-range operational economy: Thrust bearing designed to absorb external pump thrusts ... carbon ring glands specially made for vertical operation ... casings and bearing housings split vertically for easy accessibility.

But most important, the Terry vertical turbine has an *almost* indestructible rotor. A single forging of special composition steel, it has no separate parts to loosen or work out. As the only function of the blades is to form a series of pockets, any wear which might occur would not materially affect horsepower or efficiency.

If your application demands a vertical turbine, specify Terry solid wheel. Available in capacities from 5 to 300 horsepower. And remember, the extra durability built into these vertical turbines is typical of every turbine in the complete Terry line.

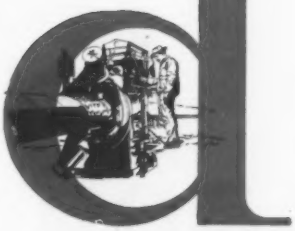
For further information, send for a copy of bulletin S-137.

THE TERRY STEAM TURBINE CO.
TERRY SQUARE, HARTFORD 1, CONN.

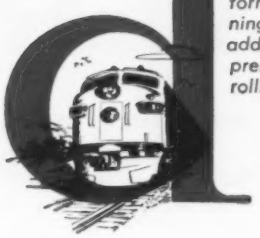
TERRY

TT-1210

dearborn *research leads the way in all fields of corrosion control*



PIPE LINE *corrosion specialists call for both mechanical and chemical protection and get it with Dearborn's NO-OX-ID* coatings and wrappers . . . underground and underwater protection that lasts for decades.*



ON RAILROADS, *Dearborn's water treatment formulas and sludge solvents keep diesels running longer and cleaner. NO-OX-ID* coatings add years of life to trestles and bridges. Exclusive pressure washing systems and cleaners keep rolling stock bright . . . reduce maintenance costs.*

SHIP OWNERS *depend on Dearborn's NO-OX-ID* coatings for long term protection against the continuous corrosive attack of inland and salt waters.*

POWER ENGINEERS *in all types of industry keep costly boiler down-time and repairs at a minimum . . . maintain trouble-free cooling systems . . . with Dearborn water treatment consulting service and test equipment engineered to their specific needs. Dearborn engineers also assist in designing pre-treatment systems including ion-exchange equipment, demineralizers and softeners.*

If your responsibilities include any phase of water treatment or corrosion control, you should be receiving Dearborn's valuable research and technical bulletins. A request on your Company letterhead will bring them regularly.

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pioneer in the science of corrosion control

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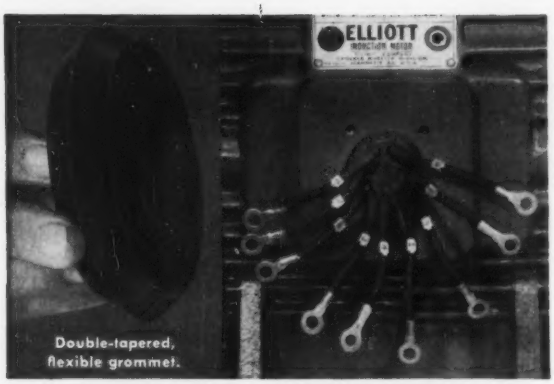
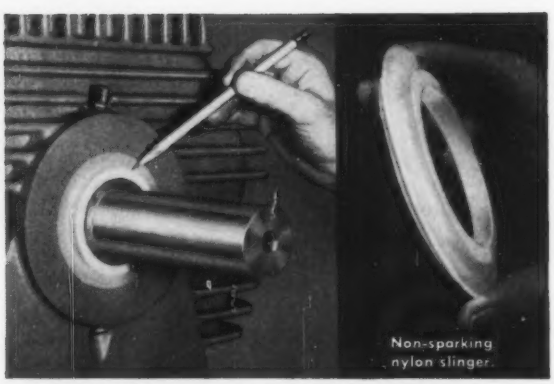
better protection and better cooling make Elliott C-W SEALEDPOWER MOTORS

outstandingly



TIGHTLY COMPRESSED GROMMET seals leads where they leave motor frame. Grommet is compressed around numbered leads by pressure ring. No leakage here.



ROTATING SLINGER BANISHES MOISTURE, DIRT that otherwise might creep along shaft and through bearing. Recessed into bracket, it provides long labyrinth-type seal.

IMPORTANT FACTS
about enclosed motors are given in new Elliott Bulletin PB-6000-2. Send for free copy today.

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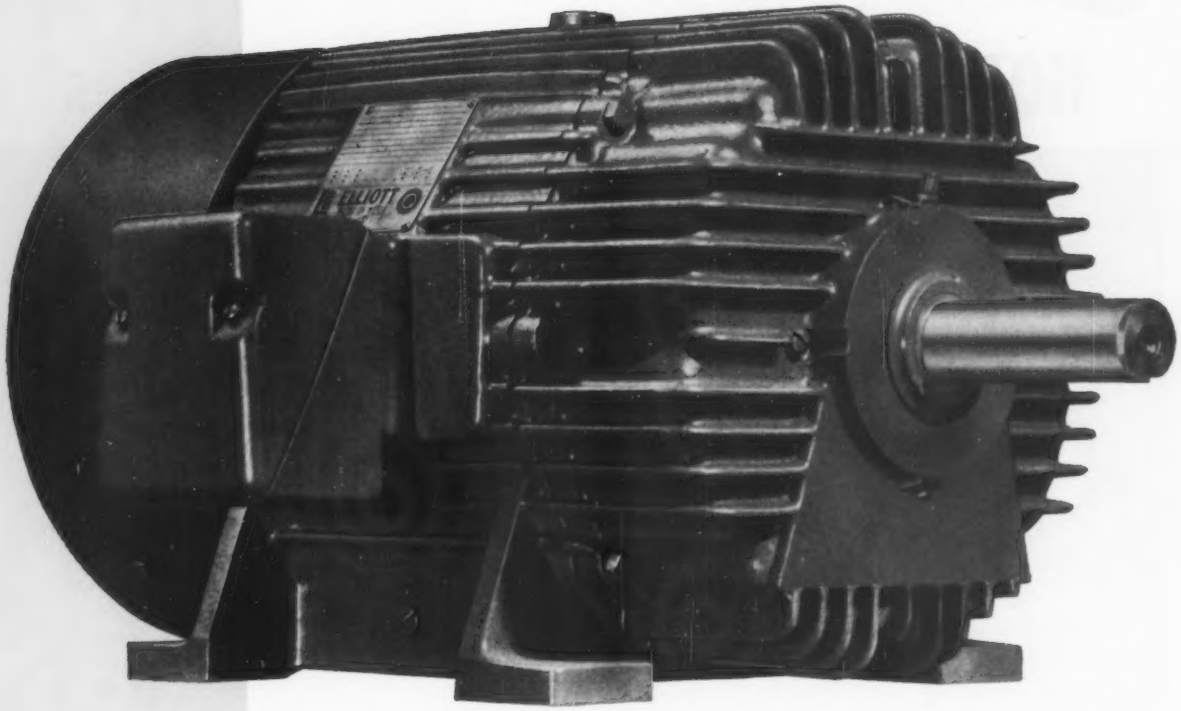
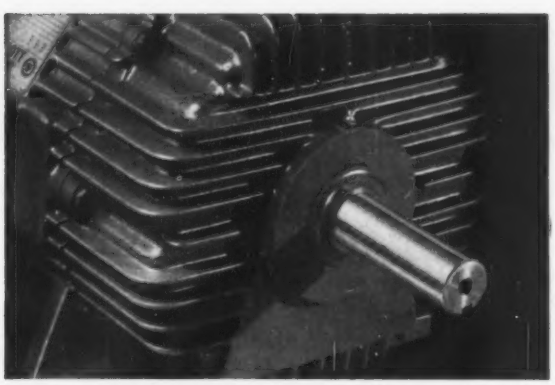
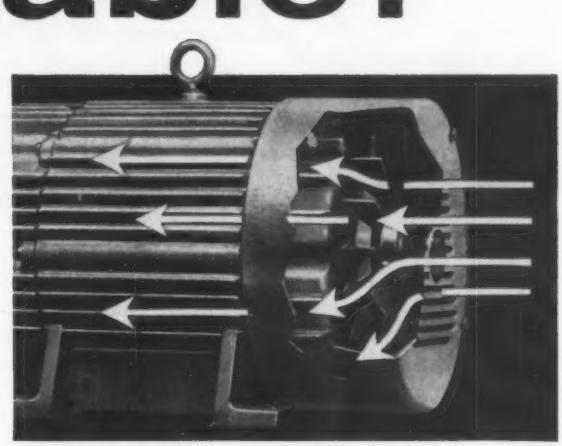
Elliott C-W ribbed-frame enclosed motors, pioneered in the United States by Crocker-Wheeler, include ratings up to 300 hp.



dependable!



MORE AND DEEPER HEAT-RADIATING FINS have greater cooling area. Generous fins over rear bracket keep bearing cool. Non-clogging, easy to clean.



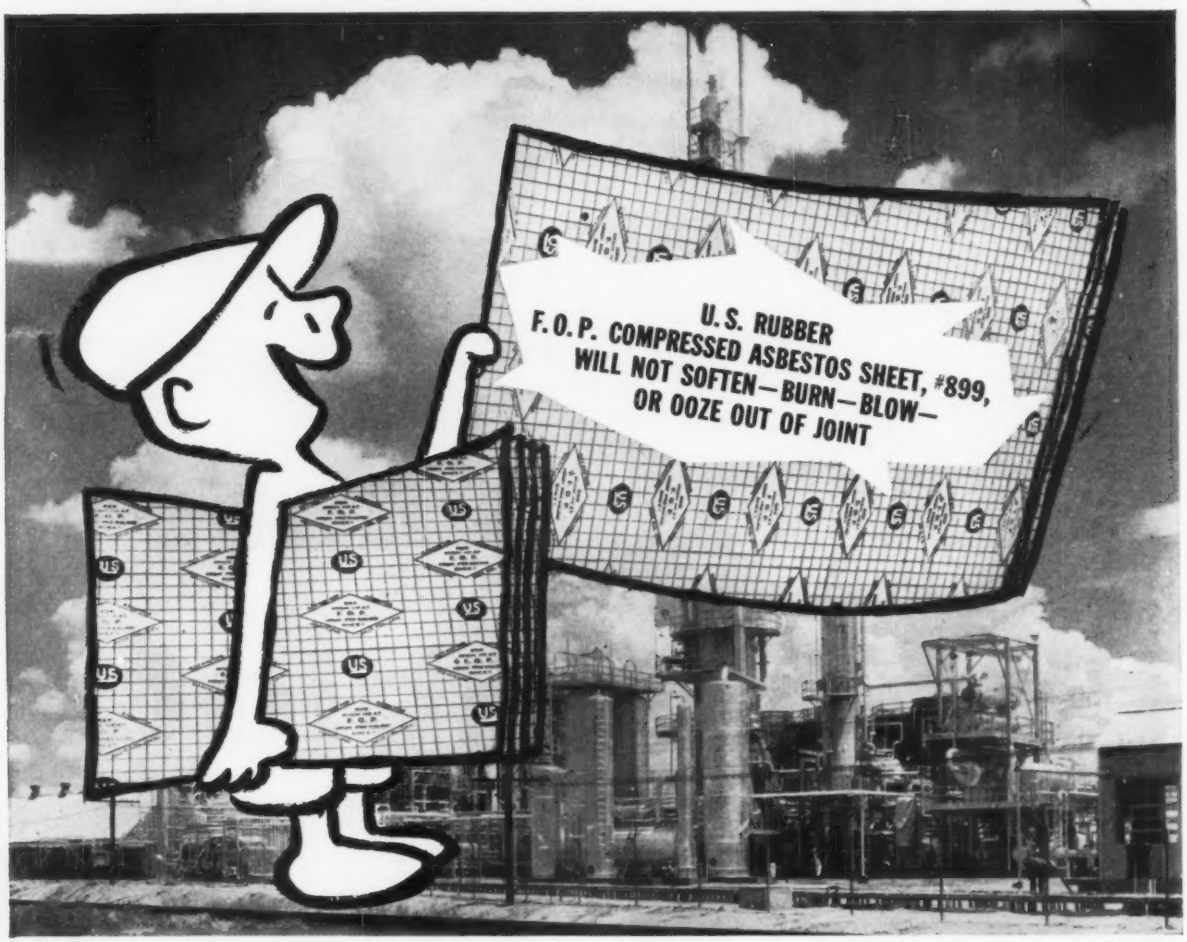
COOLING AIR BLAST FROM EXTERNAL FAN, directed by fan cowl, hugs entire length of motor. Non-sparking fan has keyed and clamped split hub.

ELLIOTT Company

CROCKER-WHEELER PLANT • JEANNETTE, PA.

US RUBBER PACKING

HOT NEWS for Hot Joints and Flanges



This is the packing that's making headlines where the going's the hottest . . . where flanges or joints must be packed against superheated or saturated steam, air, water, ammonia, gases, oil, gasoline and many chemicals.

U.S. Compressed Asbestos Sheet Packing was the first of its type developed particularly for refineries and chemical plants. It is made by a special process from selected long-fibre asbestos and bonded with exacting combinations of heat-resistant materials. Balanced construction makes this packing ideal for use as Still Head Gaskets.

U.S. Rubber Compressed Asbestos Sheet Packing can be furnished in a variety of constructions, each specially suited to a specific requirement. They are some of the hundreds of styles of U.S. Rubber Packing available.

• • •

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Mechanical Goods Division

United States Rubber

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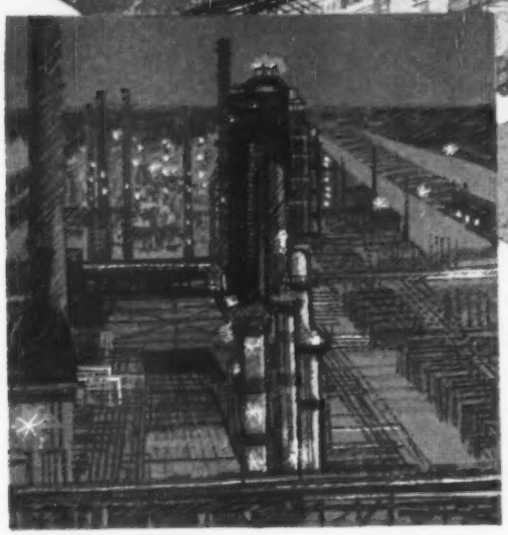
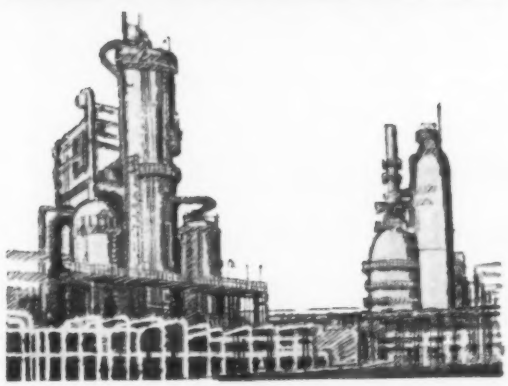
Rockefeller Center, New York 20, N.Y. In Canada: Dominion Rubber Company, Ltd.

Who we serve proves *how* we serve





Since 1923, the world's leading petroleum refineries, chemical plants and other process installations have operated with the aid of Pacific centrifugal pumps. Their satisfaction with the cost-cutting efficiency provided by Pacific pumps is apparent in continuing repeat orders for plant expansion and new facilities.

There are several advantageous reasons for these re-orders; among them: (1) Pacific is a specialist in the development, design and manufacture of centrifugal pumps. (2) Pacific manufactures a wide variety of types and sizes to fill specific needs at the most beneficial cost/efficiency level. (3) Pacific provides technical advice and counsel to customers through an experienced sales engineering staff. (4) Pacific pumps may be financed in the leading currencies of the world.

There are other reasons why Pacific can serve you best. We would welcome an opportunity to tell you about them.

PACIFIC

Offices in all Principal Cities

PACIFIC PUMPS

Inc. . . A Division of Dresser Industries, Inc.

HUNTINGTON PARK, CALIFORNIA

IN-3

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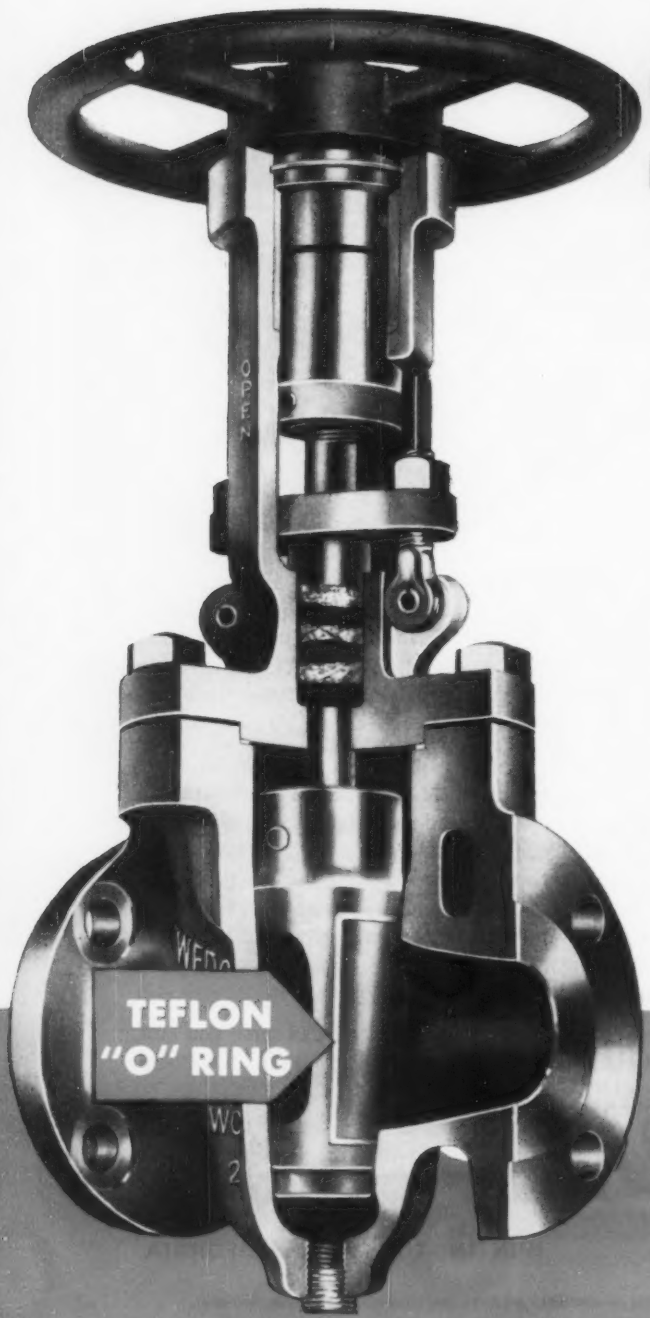
BIGGEST MONEY SAVER

In The Valve Industry!



You're familiar with the expense involved in the lubrication of plug valves — the high monthly cost of man hours, grease and equipment, or of a lubrication service. The contaminating influence of the lubricant is also a constant hazard. Not to mention the sticking and leakage that occur when lubrication of a particular valve is overlooked.

These are some of the reasons why Stockham's Wedgeplug "O-Seal" Valve is rapidly replacing lubricated valves in general purpose services everywhere.

The other reason is, simply, that the non-lubricated "O-Seal" equals or betters the performance of any lubricated valve — without costing a cent for maintenance.

Two Teflon† "O" rings in the plug provide absolute shut-off — shut-off that remains permanently "bubble-tight" on both the upstream and downstream seats. Thus, the "O-Seal" provides double-block and bleed in most services. The "O-Seal" has proven itself absolutely leakproof on hundreds of services.

Flawless machining of metal seats provides shut-off in case of fire — double seating for double *safety*. And the "O-Seal" is *guaranteed not to stick*.

Call your Stockham Distributor or Sales Representative now, or write Stockham for complete details about how you'll save money — from now on — with

Stockham's NON-LUBRICATED Wedgeplug* "O-Seal" Valve

Complete ranges of sizes and types available.

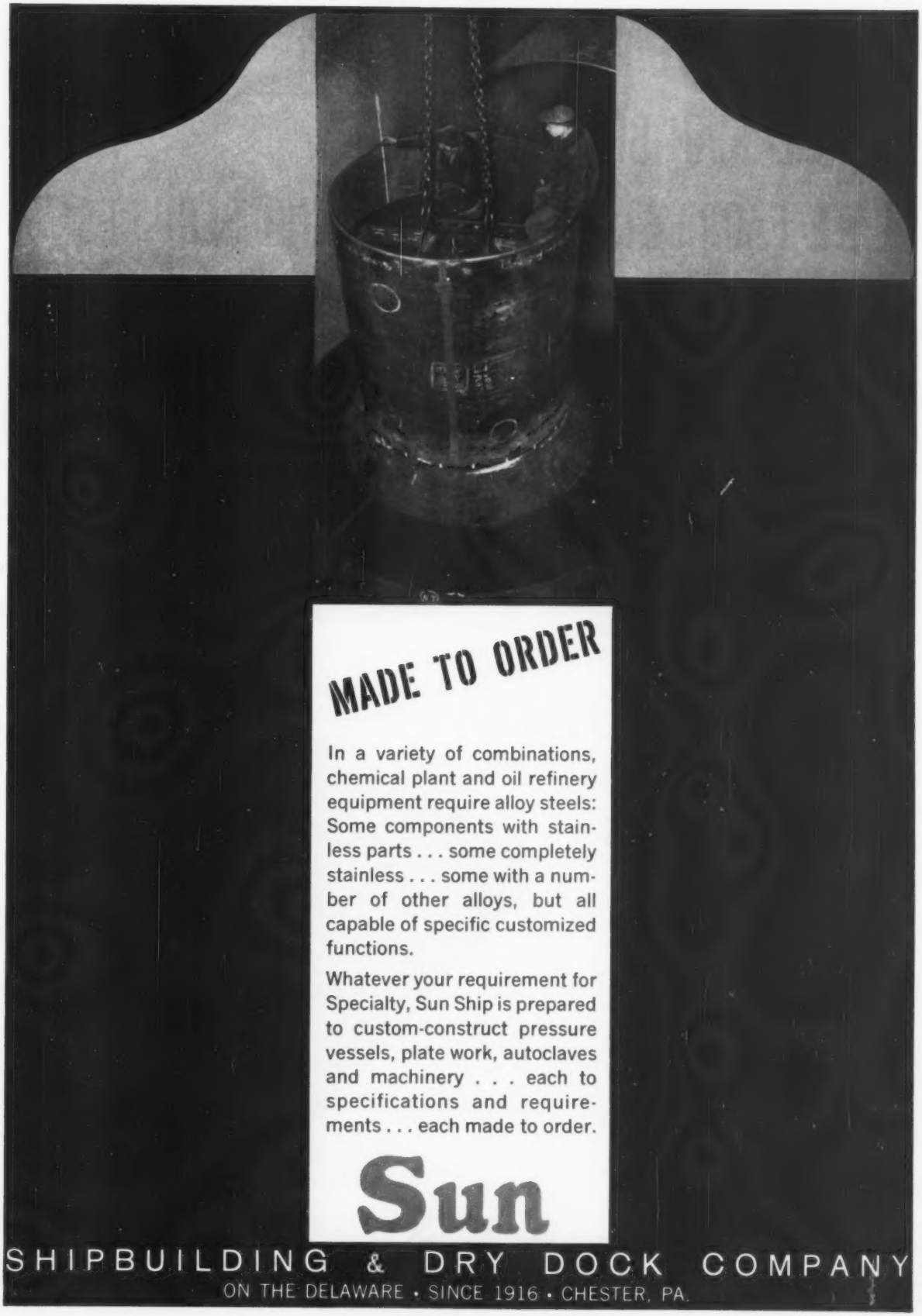
†Teflon, Dupont Trademark *Patented

WEDGEPLUG VALVE COMPANY
DIVISION OF

STOCKHAM
VALVES *and* FITTINGS

General Offices and Plant
4000 North 10th Avenue Birmingham 2, Alabama

CAST IRON-MALLEABLE AND DUCTILE IRON PIPE FITTINGS — BRONZE, CAST IRON, DUCTILE IRON, CAST AND FORGED STEEL VALVES
Sold Only Through Distributors


MADE TO ORDER
In a variety of combinations, chemical plant and oil refinery equipment require alloy steels: Some components with stainless parts . . . some completely stainless . . . some with a number of other alloys, but all capable of specific customized functions.
Whatever your requirement for Specialty, Sun Ship is prepared to custom-construct pressure vessels, plate work, autoclaves and machinery . . . each to specifications and requirements . . . each made to order.
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SHIPBUILDING & DRY DOCK COMPANY
ON THE DELAWARE • SINCE 1916 • CHESTER, PA.

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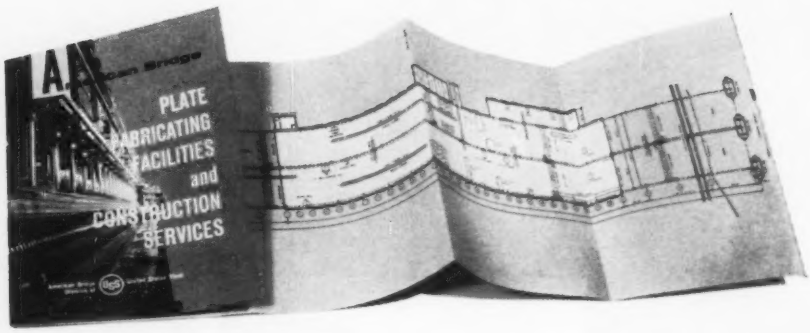
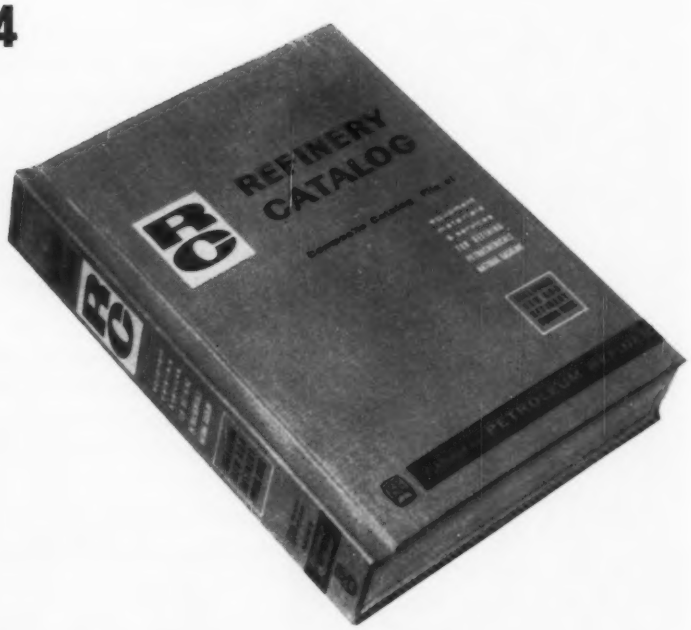
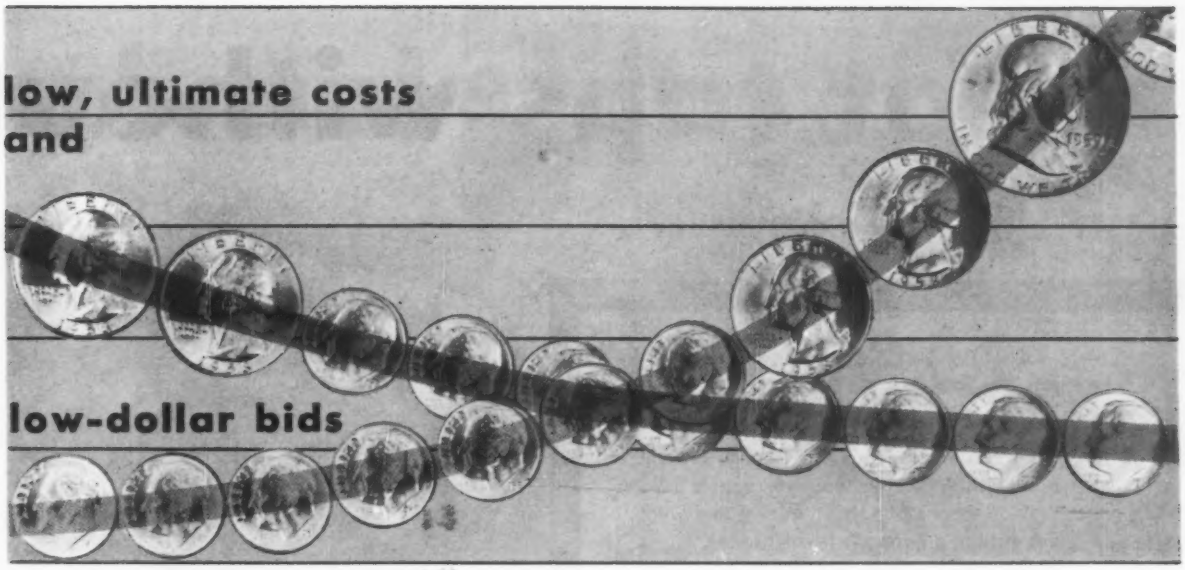
FOR COMPLETE INFORMATION ON AMERICAN BRIDGE PLATE FABRICATING FACILITIES AND SERVICES CHECK OUR INSERT



. . . ON PAGES 217 - 234 OF THE 1960 REFINERY CATALOG



American Bridge Division of USS United States Steel



are not the same

The historic struggle between long-range economy and "low-dollar" first-cost is brought into extremely sharp focus in the competitive bidding for heat transfer equipment sales in the process industry . . . especially where *continuous flow* processes are involved.

Recognition of *all* factors contributing to the economy of such continuous, uninterrupted operations has become the cornerstone of Western's appraisals and solutions. It is further reflected throughout the design, mechanical, thermal and rating phases of the engineering of each Western Heat Exchanger.

Western engineers understand this "fact of life": we must, to the best of our ability, anticipate the *continuing expense* of operation and maintenance of heat exchangers, so that such ultimate costs are kept at a minimum, and our exchangers *operate at a profit* for our customer. Otherwise, it is false economy indeed, regardless of the "initial cost."

Western Heat Exchangers are quoted for *long-range economy,* not short-sighted "low-dollars" . . . and a visit with a Western engineer will show you how and why.

WESTERN'S STAKE IN YOUR FUTURE

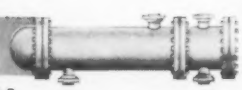
In today's "business arena" it is increasingly important for process engineers to take the *full* look at *true economy* in the production of chemical and petro-chemical products. Pointing to the need for such understanding is the next of Western's "professional-advancement" messages, shown at right, currently seen in leading petroleum and chemical trade journals . . . and available in more complete detail in pamphlet form, upon your request.

One of a series appearing in OIL & GAS JOURNAL, CHEMICAL ENGINEERING, PETROLEUM REFINER, REFINING ENGINEER, CHEMICAL ENGINEERING PROGRESS.

serving the growth of the process industry

WESTERN

HEAT EXCHANGERS



WESTERN SUPPLY COMPANY

P.O. Box 1888 – Tulsa, Oklahoma

"LOW FIRST-COST vs. LOW ULTIMATE COST" controversy demands understanding of economics involved

When is a "low bid" really low? This perplexing question consistently faces the engineer charged with the responsibility of ordering capital process equipment with a wary eye towards the profitability of such equipment in his company's long-range economy, yet, beset with the necessity for tightly-budgeted current operations.

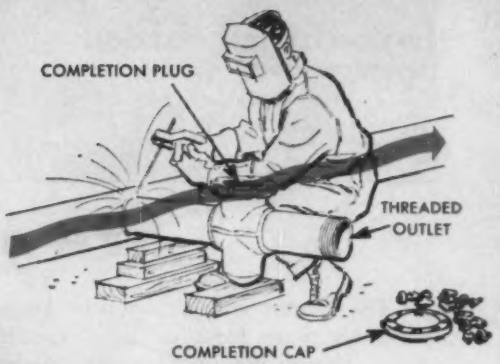
For more data on advertised products, use Readers' Service Cards, last page.

hot taps without

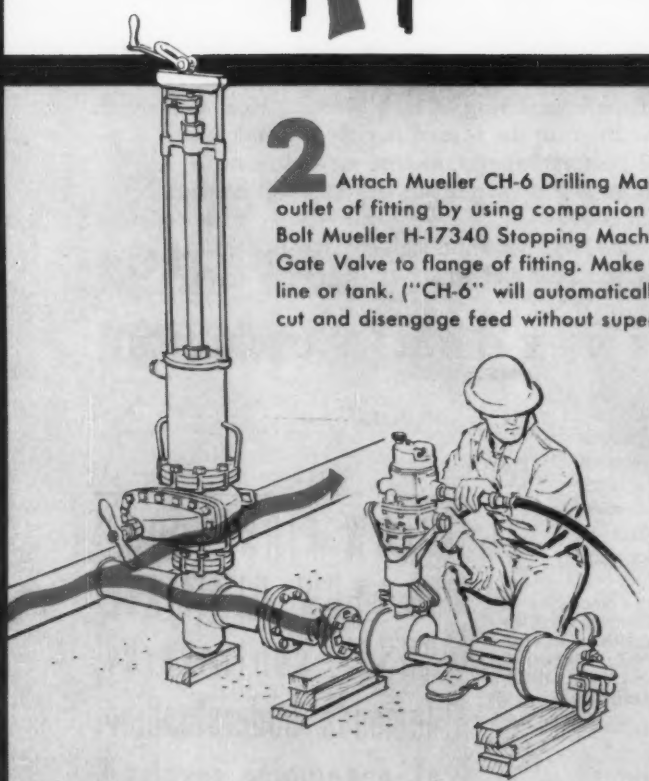
PROBLEM:

Tie in a new, permanent 6" line to present operating system without interrupting flow. Provide means of valving in new line without installing permanent valves.

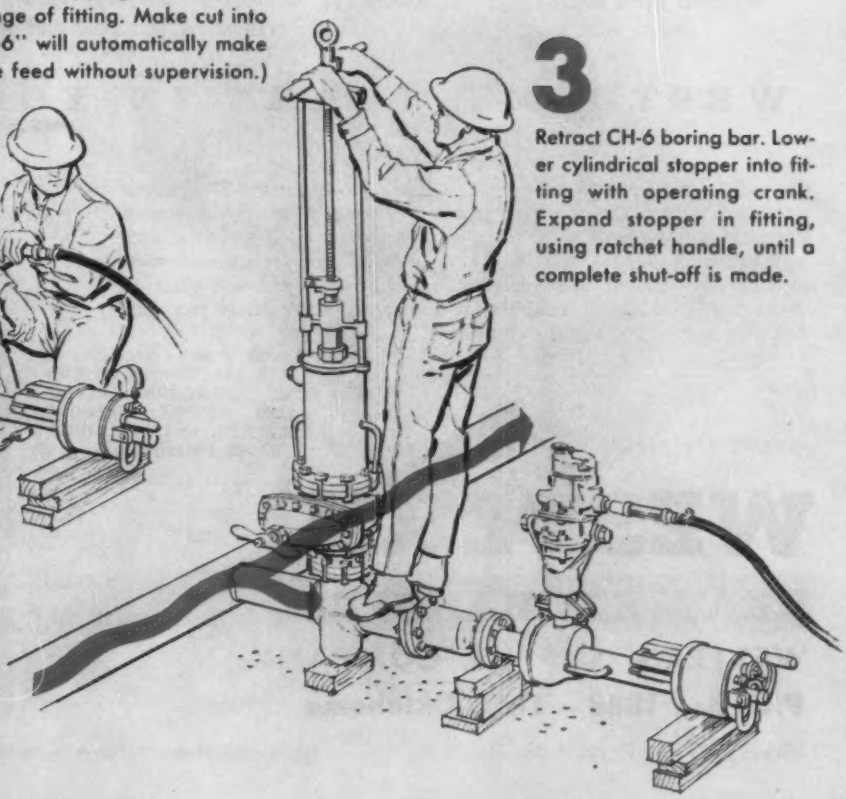
HERE'S HOW



1 Weld exclusive Mueller Extension Stopper Fitting to operating line. (6" fitting shown. Other sizes from ¾" to 8" available.)



2 Attach Mueller CH-6 Drilling Machine to outlet of fitting by using companion flange. Bolt Mueller H-17340 Stopping Machine and Gate Valve to flange of fitting. Make cut into line or tank. ("CH-6" will automatically make cut and disengage feed without supervision.)



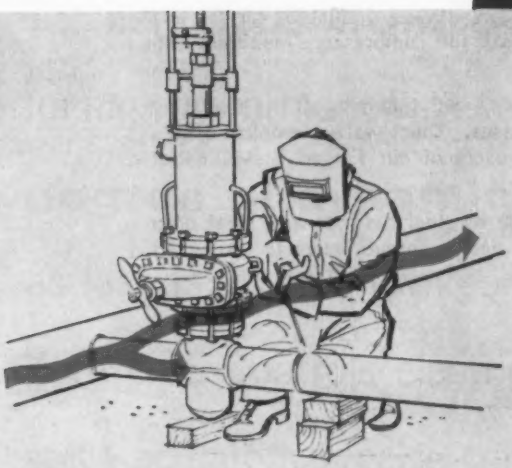
3 Retract CH-6 boring bar. Lower cylindrical stopper into fitting with operating crank. Expand stopper in fitting, using ratchet handle, until a complete shut-off is made.

valves!

FIRST IN A SERIES

on applications of

MUELLER® NO-BLO® METHOD

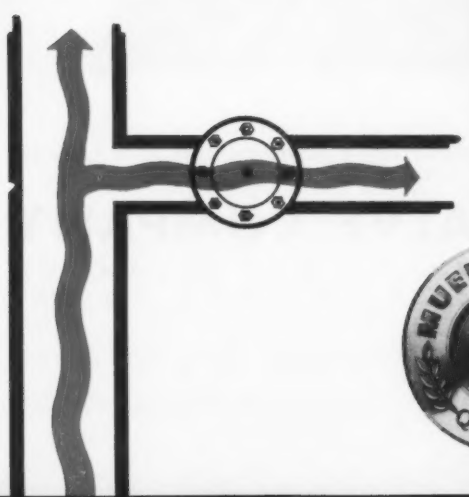


4 Remove CH-6 Machine. Attach new line to fitting and extend to next valve or complete unit. (Companion flange may be used to connect line or threads may be cut off for welding connection.)

5 Equalize pressure in new line. Contract and raise stopper. Close valve and remove stopping machine. (New piping is now under full pressure.) Bolt Mueller H-17346 Completion Machine to gate valve, open valve and screw completion plug into top of fitting. Remove machine and gate valve and bolt completion cap to flange of fitting.

SOLUTION:

Line has been safely tied in under full system pressure without shutdown or other disturbance to operating facility. Only maintenance-free fitting remains in new line—no valve! Stopping machine may be re-mounted on fitting and line stopped-off whenever needed.



These fittings and machines are just a small part of Mueller's complete system of No-Blo products—products especially designed for use with operating fluid facilities.

No-Blo products and methods make it possible to extend dead ends, to transfer service to another line, to isolate a section of line, to repair leaks, to make tie-ins, to run laterals, to install or replace equipment—all under full operating pressure in a safe, controllable manner and without shutdown!

The No-Blo System is typical of the constant attention to detail—and more than a century of experience—in research, design and engineering that is a part of all Mueller fittings and equipment.

Mueller also manufactures a full line of components for gas and water distribution systems, fire protection systems and plumbing systems.

Write for complete information and specifications.

MUELLER CO. since 1857 SERVING the Water and Gas Industries QUALITY

MUELLER CO.

DECATUR, ILL.

Factories at: Decatur, Chattanooga, Los Angeles;
In Canada: Mueller, Limited, Sarnia, Ontario

ORBIT ADDS VALVES TO INDUSTRIAL LINE

ORBIT CAST STEEL VALVES FOR HYDROGEN AND SIMILAR INDUSTRIAL GASES

As an addition to our line of valves handling hydrogen, similar industrial gases, and hydrocarbons, Orbit Cast Steel Valves have proven ideal for compressor, manifold, off-site and block valve installations.

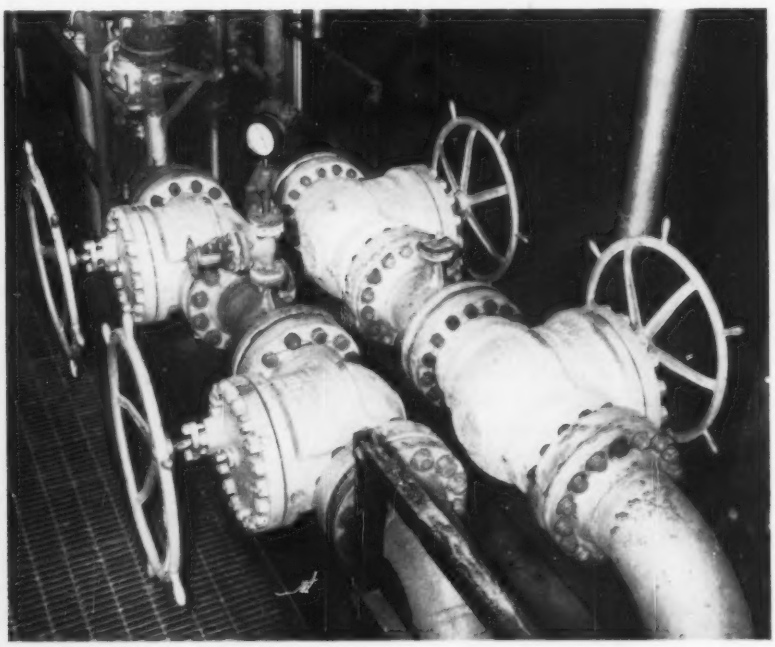
Orbit Cast Steel Carbon Trimmed Valves are particularly well suited to all the operating problems attendant to safest handling of industrial gases. These valves employ Orbit's friction-free seating principle already well known to users of our Forged Steel line of Industrial Valves.

All principal parts of Orbit Cast Steel Valves are made of steel castings and steel drop forgings, with bonnet bolted to body. A stem locking device permits valve to be locked open or closed. 2½ to 3 turns opens or closes valve.

SIZES: 5", 6", 8" & 10" *Series 300 and 400 Flanges
5", 6" & 8" *Series 600 Flanges
5" & 6" *Series 900 Flanges

Above sizes except 10" available in Screwed Ends.
*End to End Dimensions are Special.

ORBIT CAST STEEL VALVES INSTALLED ON HYDROGEN GAS COMPRESSOR MANIFOLDS IN A LARGE OHIO REFINERY.



ORBIT VALVES®

Available through your favorite supply house. Or, write Orbit today for complete information and specifications.

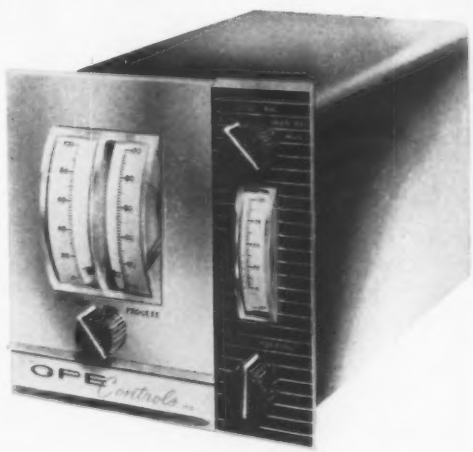
ORBIT VALVE COMPANY

P. O. BOX 699, TULSA, OKLAHOMA
PHONE LUTHER 4-4761, TWX TU 925

Electronic controllers for high-performance systems!

The new **GPE Controls** R465 Electronic Controller is built for high performance in every aspect...the result is the **highest degree of dynamic accuracy** possible. Three times as fast as other known control systems, yet comparably priced. With GPE Controls electric transmitters and electro-hydraulic valve actuators, precise control can be maintained at more than 20 cps. Easy, low-cost installation, because high-level d.c. signal makes possible simple unshielded wiring. Instant visual comparison of parallel set-point and process variable indicators.

GPE Controls R465 Electronic Controller features advanced functional design throughout. Controller drawer (left) and manual/automatic station (right) are housed in a dustproof mounting case. Either section may be serviced while the other controls the process. Proportional band, rate, and reset controls are accessible from the front while controller is operating, and are calibrated in logarithmic steps for ease in adjusting to process dynamics.



GPE Controls | A GENERAL PRECISION COMPANY

NEW factual bulletin tells the "how and why" of electronic control. Write for your copy today!

GPE Controls, Inc. (formerly Askania Regulator Company)
240 East Ontario Street • Chicago 11, Illinois

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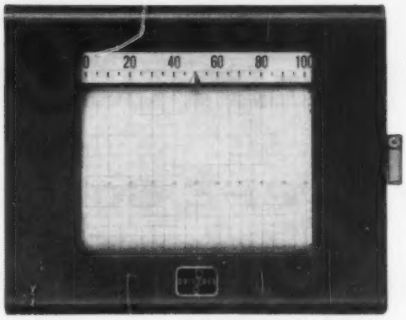
World's first mobile, self-contained nuclear power plant and first U. S. gas-cooled reactor for generating power—these are the dual aims of the Gas-Cooled Reactor Experiment Program (GCRE-I), being carried out at the National Reactor Testing Station, Idaho, for the U. S. Army and U. S. Atomic Energy Commission by Aerojet-General Nucleonics.

We're proud that Aerojet-General, prime contractors for the Army Gas-Cooled Reactor Systems Program and builders of both the reactor and its control system, selected Bristol Dynamaster* potentiometer and bridge instruments to record vital reactor data.

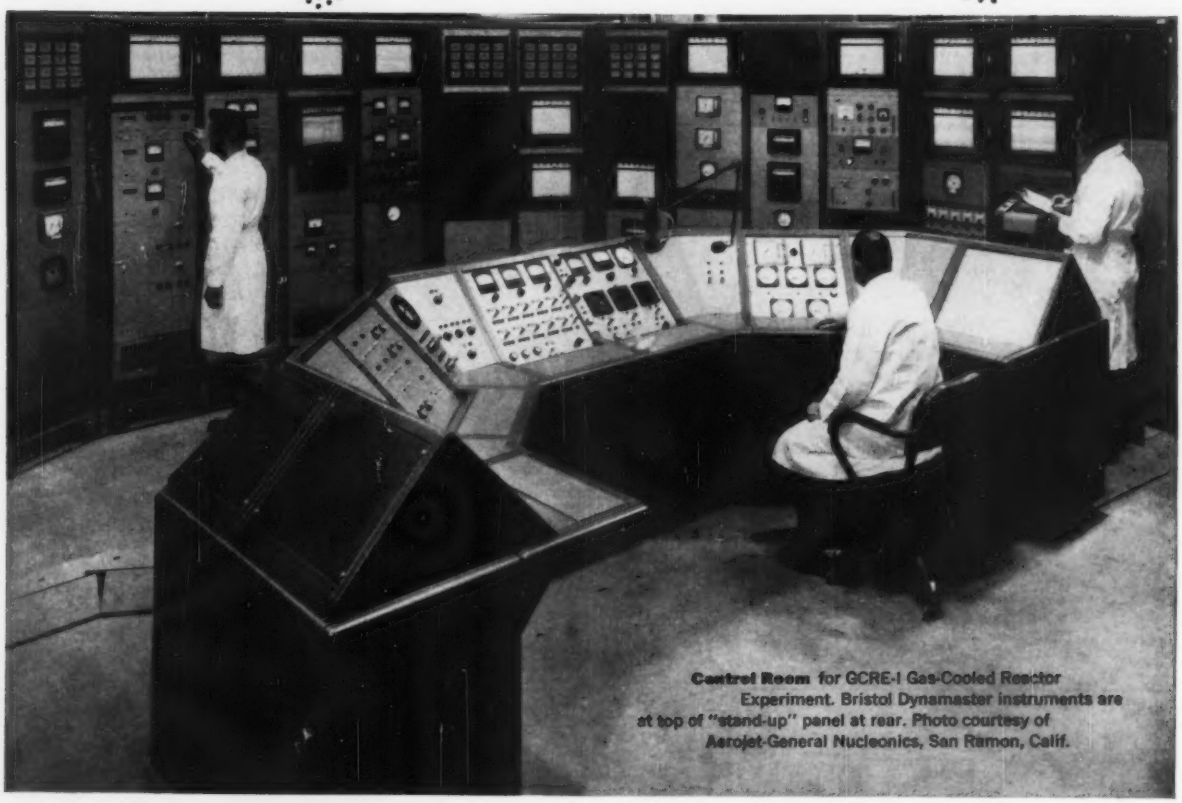
Bristol offers control-systems builders—whether for the nuclear or any other industry—the widest instrument choice on the market for measurement, recording, automatic control, and telemetering. Electronic and pneumatic types. Full-size and miniature (3" strip chart) types. For complete data, write: The Bristol Company, 111 Bristol Road, Waterbury 20, Conn. 9.25

Bristol Dynamaster* Electronic Potentiometer or Bridge Instrument, strip-chart model.



T. M. Reg. U. S. Pat. Off.

BRISTOL INSTRUMENTS *record Army reactor's progress*



Control Room for GCRE-I Gas-Cooled Reactor Experiment. Bristol Dynamaster instruments are at top of "stand-up" panel at rear. Photo courtesy of Aerojet-General Nucleonics, San Ramon, Calif.

BRISTOL... for improved production through measurement and control

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

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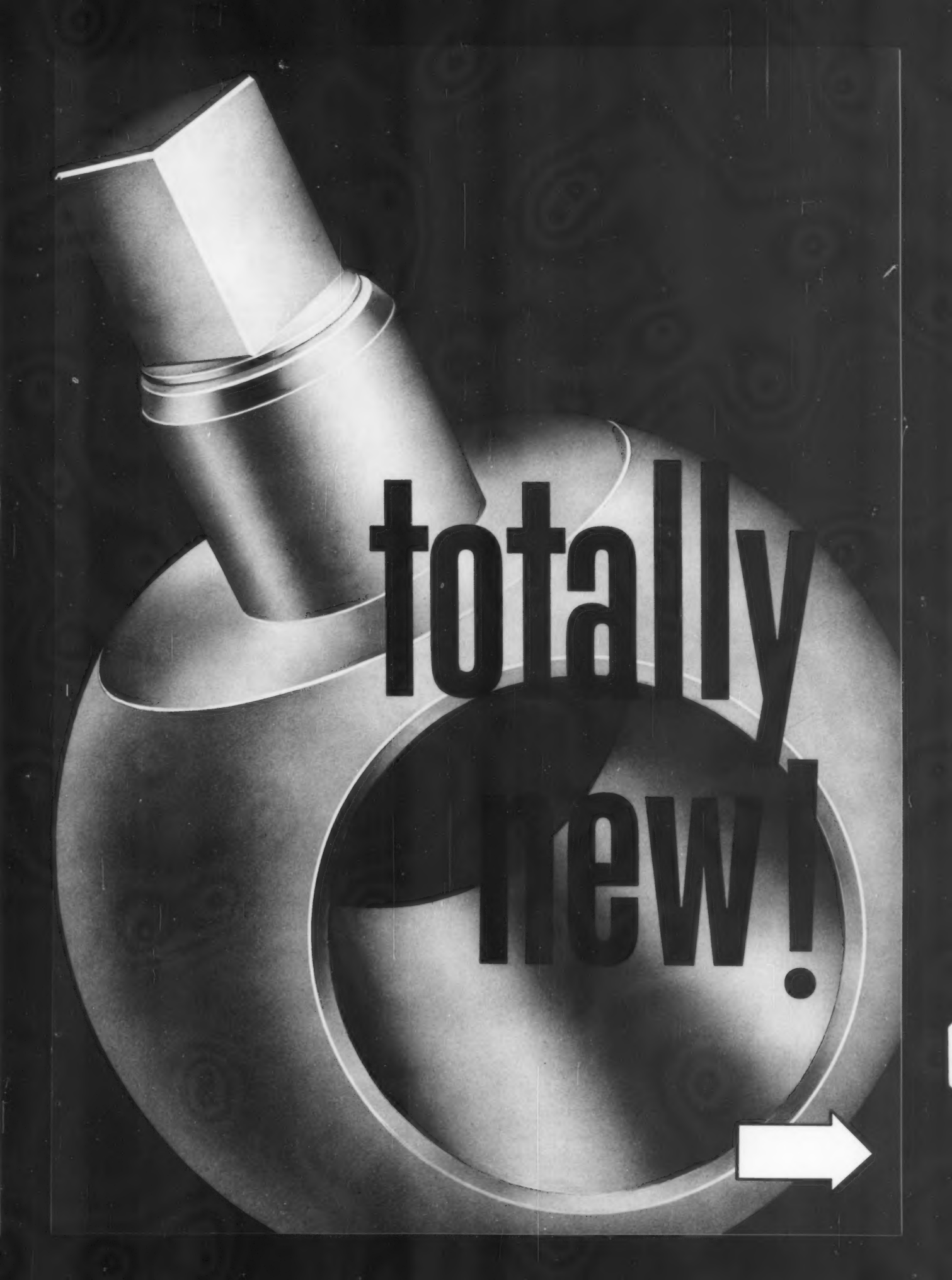
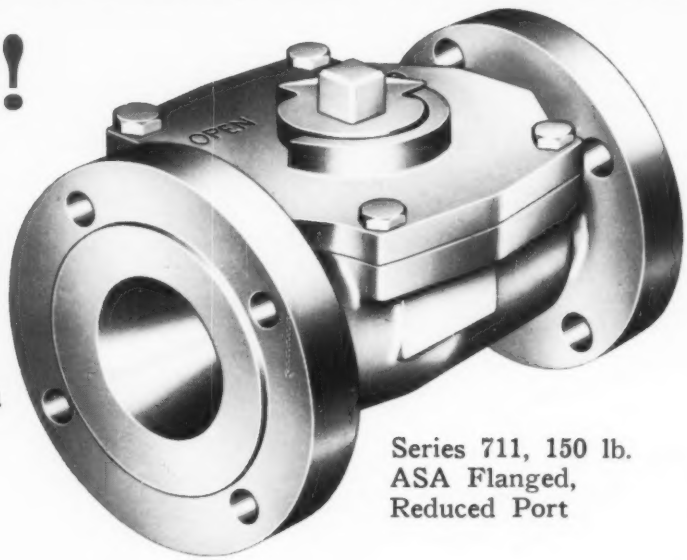

totally
new!

Only *FLO·BALL* valves are bearing-fixed for maintenance-free long life!

. . . with all the features you must have:

- **Top loading**
- **Replaceable seats**
- **One-piece ball and stem**
- **90° on-off**
- **Two-way flow**

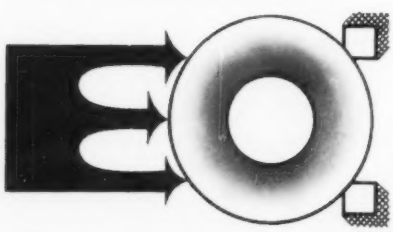


Series 711, 150 lb. ASA Flanged, Reduced Port

Now available . . . the result of years of intensive service in the missile-space industry . . . proven in thousands of adverse applications . . . now at mass produced prices . . . the most advanced line of ball valves ever manufactured . . . for you!

ORDINARY BALL VALVE

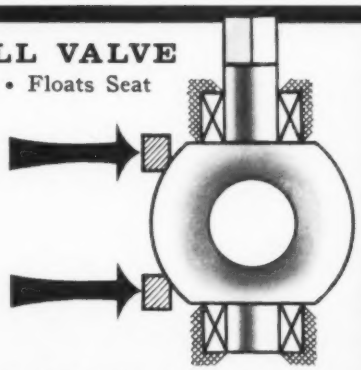
Floats Ball • Fixes Seat



Floating ball puts excessive pressure load on fixed seats. Results in distortion and short life.

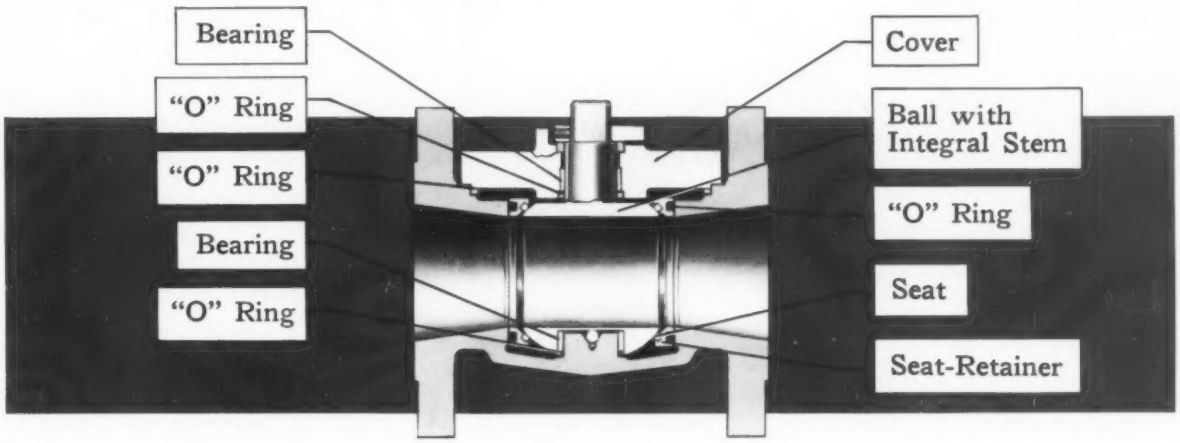
FLO • BALL VALVE

Fixes Ball • Floats Seat



FLO·BALL bearings absorb all pressure forces. Elimination of excessive seat loading insures long life.

The Series 711 ***FLO·BALL*** valves are available for off-the-shelf delivery. All are manufactured to standard ASA dimensions in semi-steel, carbon steel, 316 stainless steel, and aluminum (ASTM 356-T-6) for body and ball, Teflon for seats, and Buna "N" O-Ring seals. Other materials are also available. These valves operate at pressures to 300 psi, temperatures to 400° F.



The Hydromatics Series 711 FLO•BALL valve gives you the features you must have!

- Bearing-Fixed ball. Engineered to withstand shock and impact without distortion or backlash.
- Top loading. Valve can be disassembled and assembled without removing it from line. No special tools are required.
- Self adjusting, replaceable seats. Both balanced seats are self-aligning and self-adjusting for controlled seat loading and positive seal.
- No lubrication. Operates completely without lubrication.
- Zero leakage. At all operating pressures, including vacuum to 10^{-6} mm. of Hg.
- One-piece stem and ball. Simplified construction adds strength, precision and lower torque.
- Maximum flow efficiency. The open ***FLO·BALL*** valve provides an unrestricted, straight-thru fluid path.
- Lowest torque. Bearing-Fixed construction results in effortless, fast-action with low torque.
- Two-way flow. Exclusive ***FLO·BALL*** seat design principle insures perfect seal in both directions.

Hydromatics, Inc.

Mail this postage-free card today

Tear Along This Edge

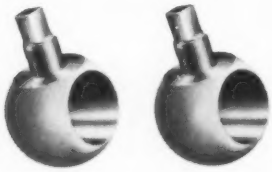
Gentlemen:
Your Bearing Fixed Flo•Ball valves from ⅛" to 24" may help solve a problem relating to the control of:

☐ Corrosive Liquids ☐ Cryogenic Liquids ☐ Throttling Flow
☐ Vacuum ☐ High Pressure

My flow problem is_____

PLEASE: ☐ Have salesman call ☐ Send technical data

My name_____ Position_____
Company name_____
Address_____
City_____ State_____



Bearing-fixed

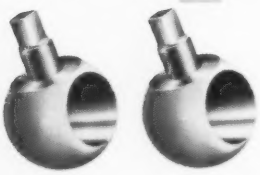
New

Zero leakage

Maximum flow

Top loading

New



No lubrication

One piece ball and stem

New

Hydromatics, Inc.

LIVINGSTON, N. J. • WYMAN 2-4900 • TWX = LIVINGSTON, N. J. 120

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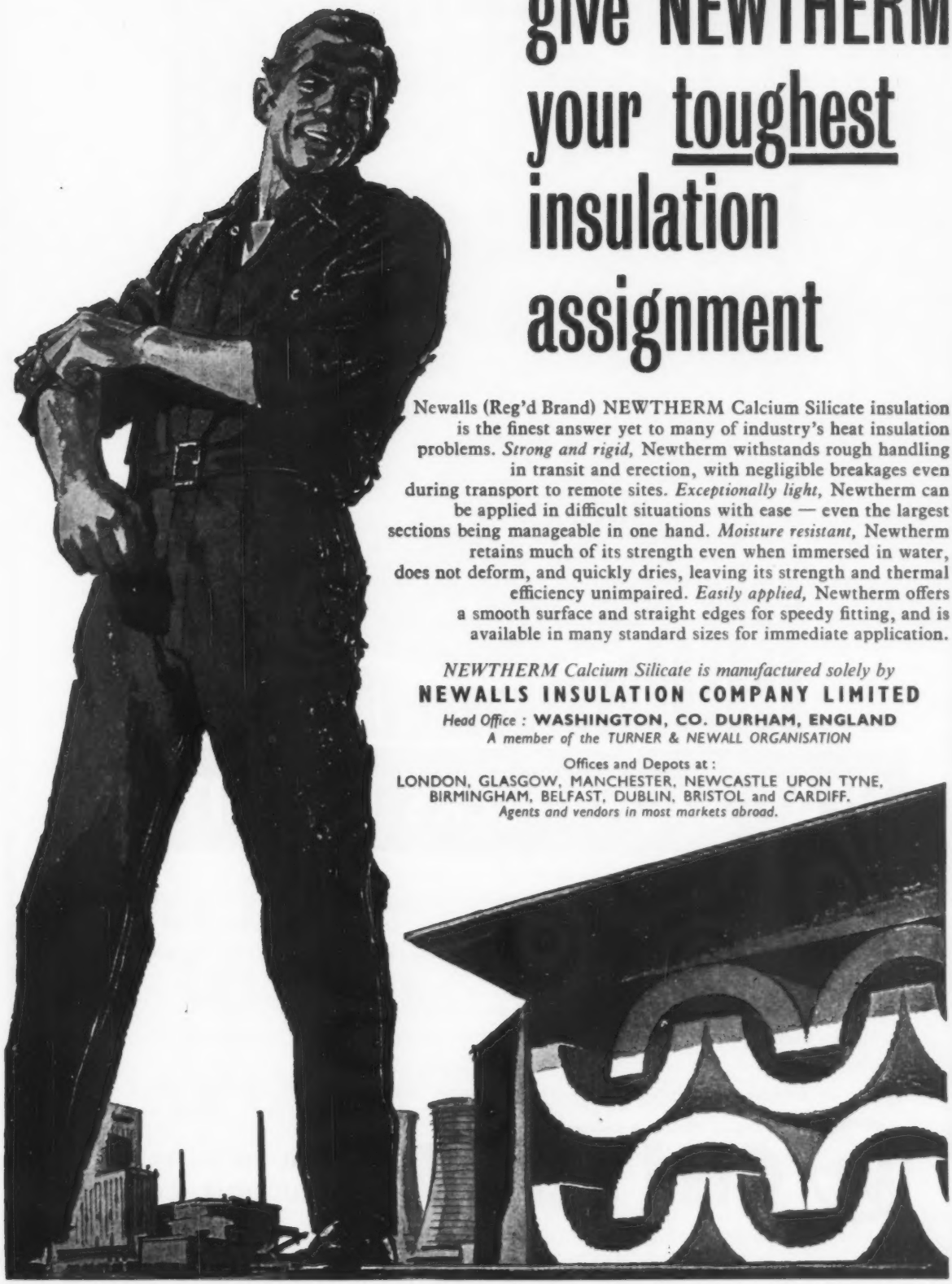


give NEWTHERM your toughest insulation assignment

Newalls (Reg'd Brand) NEWTHERM Calcium Silicate insulation is the finest answer yet to many of industry's heat insulation problems. *Strong and rigid,* Newtherm withstands rough handling in transit and erection, with negligible breakages even during transport to remote sites. *Exceptionally light,* Newtherm can be applied in difficult situations with ease — even the largest sections being manageable in one hand. *Moisture resistant,* Newtherm retains much of its strength even when immersed in water, does not deform, and quickly dries, leaving its strength and thermal efficiency unimpaired. *Easily applied,* Newtherm offers a smooth surface and straight edges for speedy fitting, and is available in many standard sizes for immediate application.

NEWTHERM Calcium Silicate is manufactured solely by

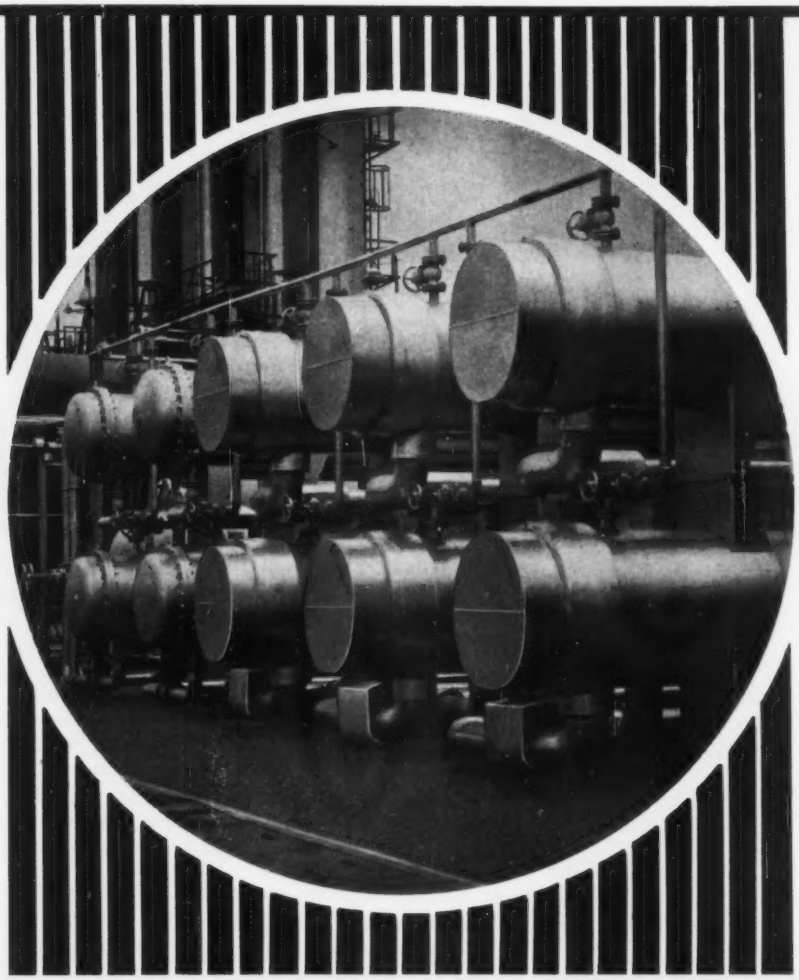
NEWALLS INSULATION COMPANY LIMITED

Head Office : **WASHINGTON, CO. DURHAM, ENGLAND**

A member of the TURNER & NEWALL ORGANISATION

Offices and Depots at :
LONDON, GLASGOW, MANCHESTER, NEWCASTLE UPON TYNE, BIRMINGHAM, BELFAST, DUBLIN, BRISTOL and CARDIFF.

Agents and vendors in most markets abroad.



HEAT EXCHANGERS BY CHIYODA

Heat exchangers, coolers, condensers and other process equipment, standard or special, large or small, single or by the scores, are fabricated by Chiyoda at Chiyoda's new Kawasaki Factory with the most modern fabricating and testing equipment using fabrication methods backed by years of experience.

With an integrated organization staffed by specialists in every field plus lower man-hour costs, Chiyoda assures clients of early delivery, low maintenance cost, high operating efficiency and long life.

For your process equipment requirements anywhere in the world, CONTACT CHIYODA.

"Process Plants & Equipment Specialists"

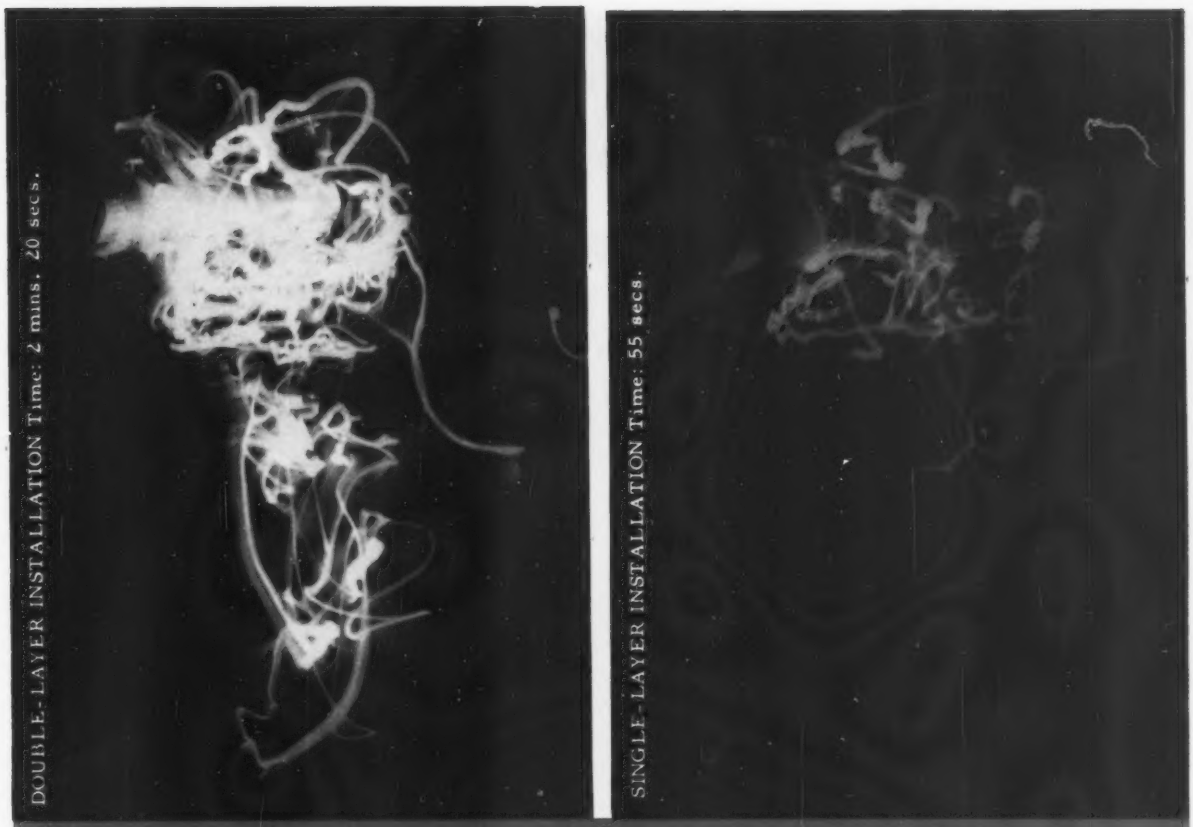
CHIYODA CHEMICAL ENGINEERING & CONSTRUCTION CO., LTD.

PRESIDENT A. TAMAKI

NO. 3, MARUNOUCHI 2-CHOME, CHIYODA-KU, TOKYO, JAPAN

Cable Address: "CHIYOTAKA TOKYO"

For more data on advertised products, use Readers' Service Cards, last page.



Photographic 'Time and Motion Study' of the application of insulation to a 4" pipe. The greater number of movements in the double-layer installation is clearly shown. (Photo by courtesy of the Aber Company of Houston, Texas, U.S.A.)

Insulation in a single layer! Caposite was developed by The Cape Asbestos Company to avoid the 'two-layer compromise' Caposite does it in one—saving considerably on installation time and costs. Caposite, the amosite asbestos insulation, is designed to withstand temperatures up to 1000° F. without loss of efficiency.

LOW JOINT LOSS

The fibrous edges of Caposite knit together at the joints giving a good heat seal and making staggered joints unnecessary.

EASY TO HANDLE

Its inherent strength makes it possible to handle Caposite in large sections for example at 2" thick for 30" n.p.s.—with very little damage and a further saving in installation costs.

One layer— Less work

CAPOSITE single-layer insulation

CAPE

THE CAPE ASBESTOS COMPANY LIMITED

114 & 116 Park Street, London W. 1, Grosvenor 6022
Cables: Incorrupt London

Enquiries in Canada to: Cape Asbestos (Canada) Limited, 200 Bloor Street East, Toronto, Ontario.
U.S.A.: North American Asbestos Corporation, Board of Trade Building, Chicago 4, Illinois.

TA 2543

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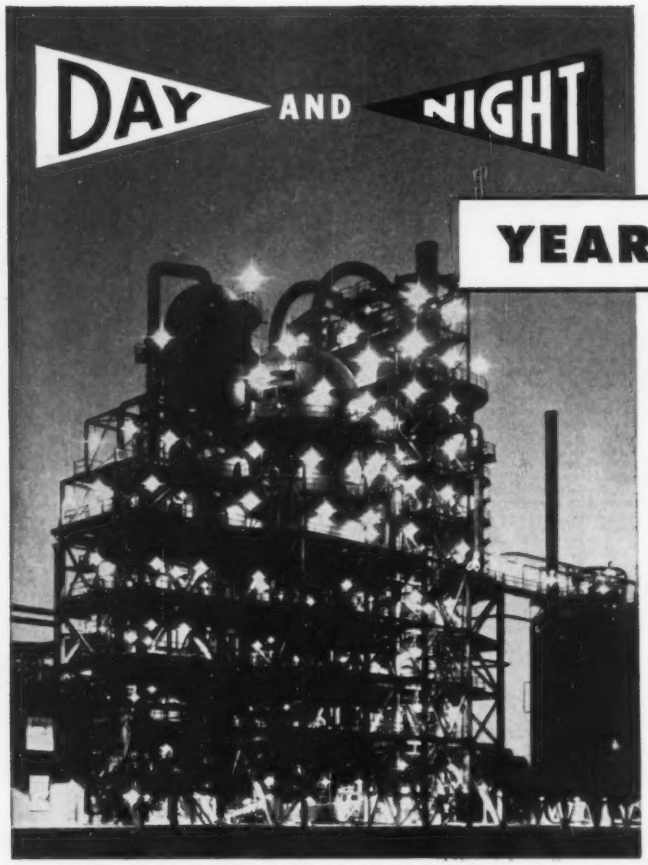


YEAR-IN, YEAR-OUT

always DEPENDABLE

LimiTorque VALVE CONTROLS

Round the clock, dependable service has been performed by LimiTorque in Refineries and High Pressure Oil and Gas Transmission Lines for a period of 27 years . . . in Canada, Alaska, Venezuela, the Middle East, Sumatra, Sahara, Mexico; all over Continental Europe, and of course, throughout the United States.

Faithful, Dependable Valve Operating Service is the big factor that has made LimiTorque famous—and it is the reason why LimiTorque is the most widely used Valve Operator in the World.

LimiTorque is available in numerous types and variations . . . all "custom built" to do the exact job you require . . . Speeds of operation can be varied over a wide range, even to the provision of two speeds in one direction of travel—and Electrical Control Equipment, such as reversing starters, relays, transformers, etc. may be included, to make a complete operating "package".

Regardless of whether valves are to be automatically operated indoors or outdoors—in sub-zero or elevated temperatures —under snowy, rainy, dusty, or bad fume conditions, there's an exact type and size of LimiTorque to meet your valve operating requirements.

Consult your Valve Manufacturer, or your nearest LimiTorque Sales Engineering Office . . . and remember, there are 27 years of continuous designing and manufacturing experience back of LimiTorque.

Send for Catalog L-550, and please use your Business Letterhead.

THERE IS NO SUBSTITUTE FOR —

LimiTorque®

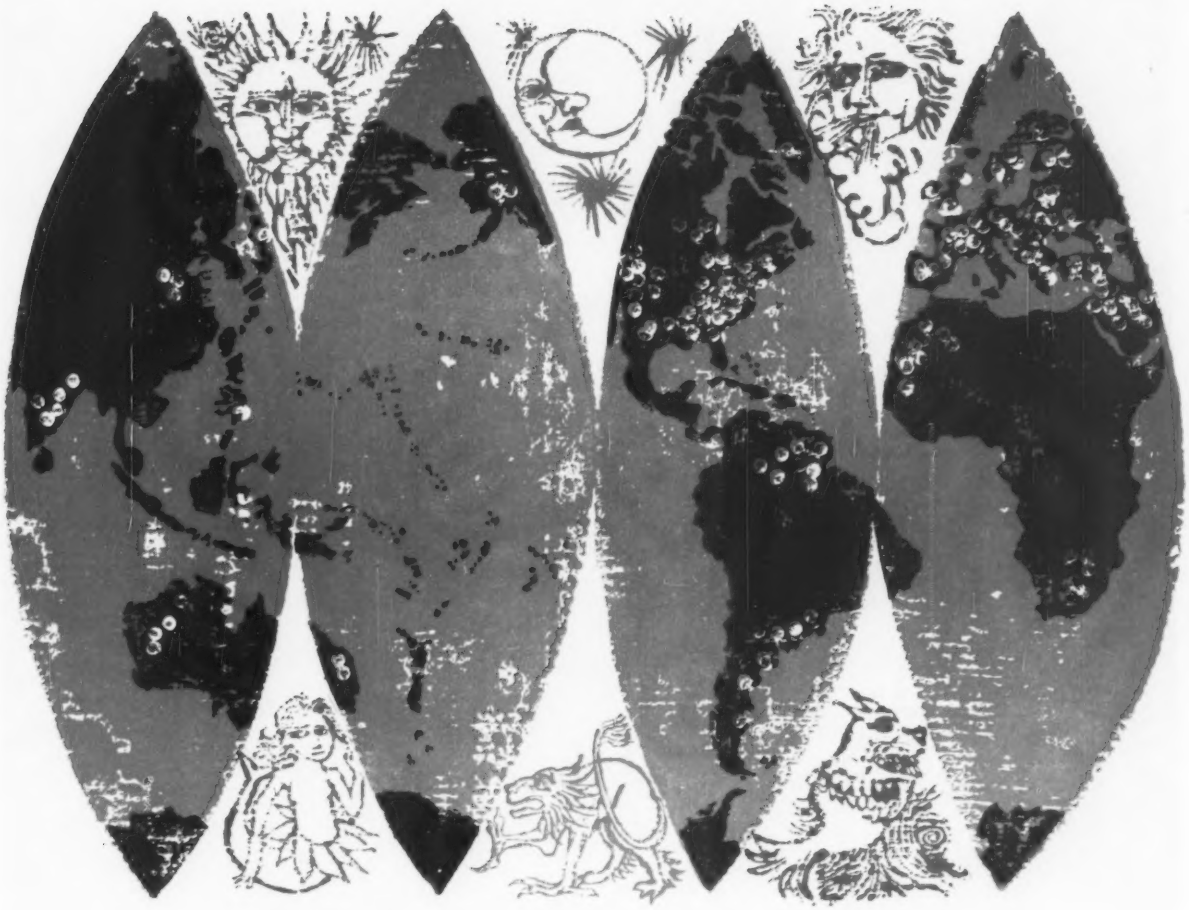
PHILADELPHIA GEAR CORPORATION

KING OF PRUSSIA (SUBURBAN PHILADELPHIA), PA.

Offices in all Principal Cities

INDUSTRIAL GEARS & SPEED REDUCERS • LIMITORQUE VALVE CONTROLS • FLUID AGITATORS • FLEXIBLE COUPLINGS

Limitorque Corporation • King of Prussia, Pa.



805 reasons a Foster Wheeler plant fits your requirements best

Wouldn't you like to find your new plant running on its scheduled completion date, meeting all specifications, and at a cost within the construction budget? The process industries have come to expect results like these when dealing with Foster Wheeler.

Would you like to see your own process plants handled by designers, engineers and construction men who have successfully put 75 different processes into efficient commercial operation?

And, if you have decided to pioneer a new process, wouldn't you like to have the advantage of Foster Wheeler's long experience with basic processing methods, such as fluidized solids, effluent refrigeration, simplified sulfonation, and efficient heat balancing in chemical operations, etc. This unique experience—plus *procurement knowledge* gained in construction of some 805 large and small plants throughout the world, and *specialized equipment know-how* available through FW's own equipment division—works for you when you use FW design, engineering and construction services.

Get specific information by discussing your process needs and plant requirements with Foster Wheeler Corporation, 666 Fifth Avenue, New York 19, N.Y.—or write for a copy of the new fully-illustrated booklet describing FW's services.

Heat Engineered products, plants and processes...for the world's industrial progress.

FOSTER WHEELER

NEW YORK LONDON PARIS ST. CATHARINES, ONT.

petroleum processing | chemical processing | specialized installations

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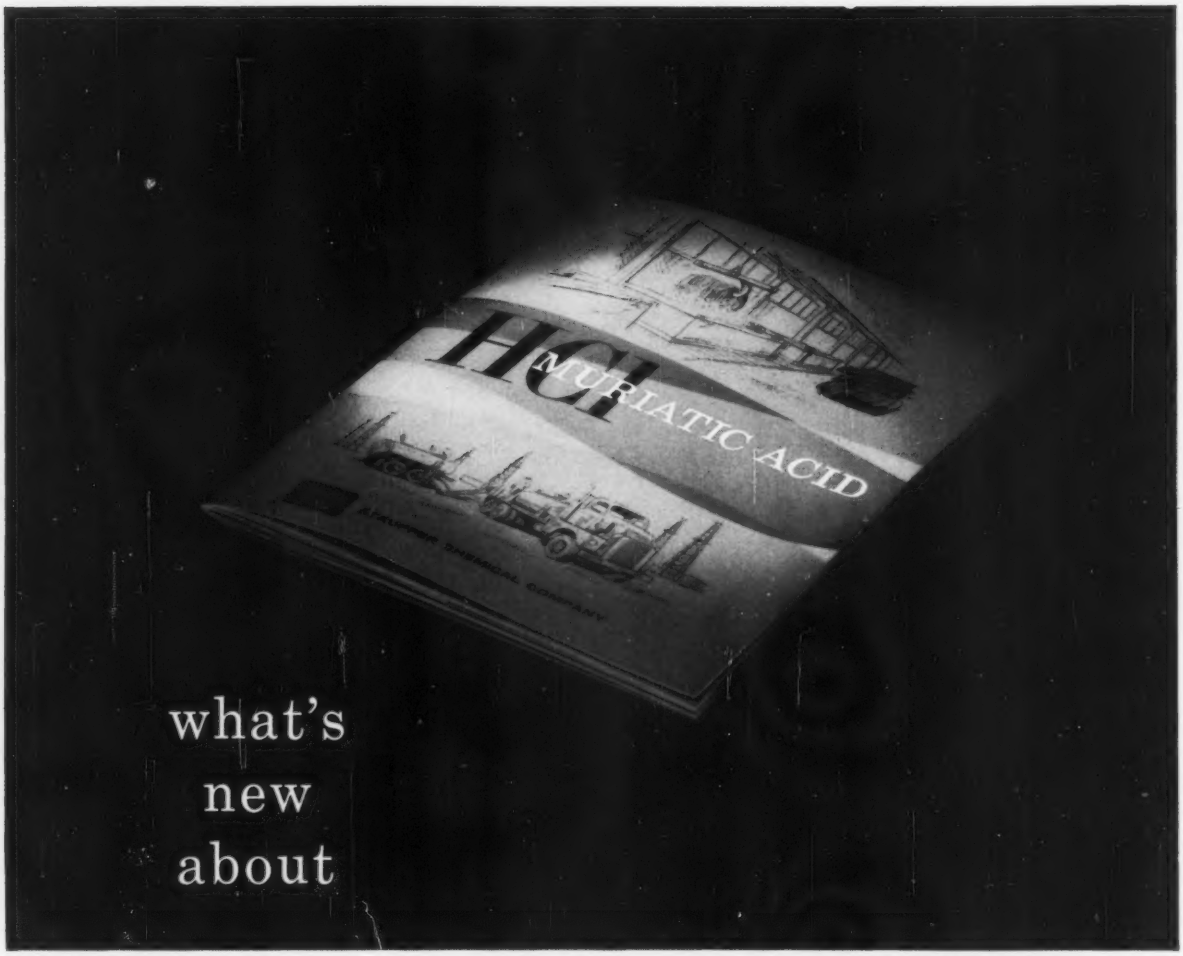

MURIATIC ACID?

To be candid... there's nothing new about the acid but there's this new and singularly complete Stauffer brochure. Pages, 44...Tables, 15...Graphs, 9... Illustrations, 24...and many pages of informative text on the major uses of Muriatic Acid.

Now ready for mailing and every consumer should have a copy. Write to either of the addresses below.

Stauffer CHEMICAL SINCE 1885

STAUFFER CHEMICAL COMPANY

380 Madison Avenue, New York 17, New York

Prudential Plaza, Chicago 1, Illinois
824 Wilshire Boulevard, Los Angeles 17, California
636 California Street, San Francisco 8, California
P. O. Box 9716, Houston 15, Texas

CONSOLIDATED CHEMICAL INDUSTRIES DIVISION, Houston 25, Texas

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"Did you look in D.J.'s locker for my P.F.I. STANDARDS?"

SEND COUPON BELOW FOR THESE P. F. I. STANDARDS

1 Machining Backing Rings for Butt Welds
2 Dimensioning Welded Assemblies
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8 Preheat-Postheat Before, After Welding
9 Arc-Welding Dissimilar Ferritic Steels
10 Stress Relieving Practices
11 Affixing Permanent Symbols to Piping

P.F.I.
THE PIPE FABRICATION INSTITUTE

There's no need to look "high and low" for missing P.F.I. Standards, you simply mail the coupon below for the copies wanted.

Listed at the left are ten technical bulletins that are proving their usefulness to many engineers.

These P.F.I. Standards are packed with vital data on the design, the fabrication and erection of high pressure and high temperature piping used by all industry. However, these technical bulletins do not explain the many advantages of shop fabrication.

Remember, shop fabrication by the companies responsible for the development of P.F.I. Standards is your only real assurance of meeting the most exacting requirements of piping, whether it's welded, bent, coiled or vanstoned . . . in any metal as a component or a complete assembly. Write for all P.F.I. Standards or indicate in the coupon below which ones could be helpful to you.

THE PIPE FABRICATION INSTITUTE

Devoted to the Technical and Economic Problems in Piping

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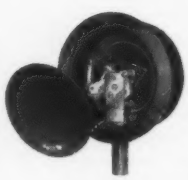
Your USG Distributor can help you . . .

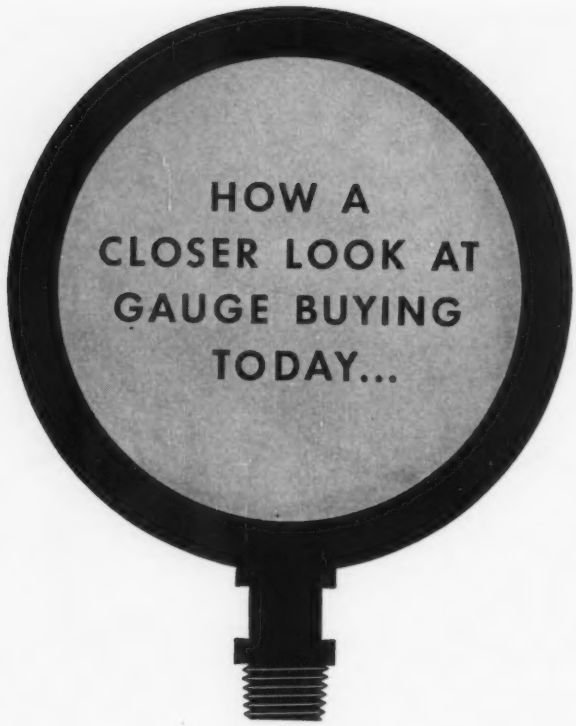
PICK Ni-Span "C" low pressure elements for exceptional thermal stability.

PICK exact Bourdon tube to meet stress, over-pressure, pressure range.

PICK Supergauge® for long life, accuracy to 0.5%.



PICK Solfrunt® for accuracy to 0.5%, solid-front safety from blow-outs.



can show you faster deliveries, more savings, widest choice

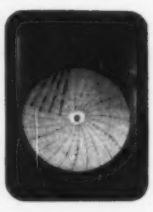
A closer look, for example, at the time spent in buying gauges from this source and that . . . or at the cost of not getting the right gauge for the right job. Then—a closer look at the nearest United States Gauge distributor . . . his facilities, service, skills in application engineering, and his USG line. He can help you pick from over 50,000 standard USG indicating dial pressure gauges . . . and thousands more in specials. The widest choice anywhere! He can streamline gauge buying, tighten up on costs, help you get the gauge accuracy and performance you need for the purpose and price . . . with one line that covers 99% of your gauge needs. Note the few examples illustrated here. Then, check the Yellow Pages for a line to your United States Gauge distributor and *simplified* money-saving *one source* buying. Or write direct for catalogs and name of your distributor.

® USG UNITED STATES GAUGE

Division of American Machine & Metals, Inc. • Sellersville, Penna.

Find Your Nearest Distributor in the "Yellow Pages"

PICK Test Gauges for dependability, and accuracy as high as 0.2 of 1%.



PICK Recorders and Recording Controllers built to stand vibration, pulsation.

PICK A-Line for premium reliability, accuracy to 1%, and savings up to 40%.

PICK Arc-Loc® Movement for longer life, easier and lower maintenance.

PICK U. S. Gauge Indicating Controllers or Transmitters for reliability.

This hypodermic could help cure your ailing gas conditioning system

This could be *your* sample ethanolamine solution that is being injected into a gas chromatograph for chemical analysis. This is just one of the many methods used by Jefferson's extensive research laboratories in Austin, Texas, to help you solve your gas processing problems. A wealth of technology and experience in such problems as high temperature corrosion, contamination, foaming characteristics, and excessive glycol losses is available expressly to serve your needs.

And whatever the findings, Jefferson has the *right* chemicals to meet your requirements in natural gas sweetening, refinery stream sweetening, sulfur recovery, carbon dioxide absorption, gas dehydration and hydrate prevention.

Monoethanolamine Diethanolamine
Ethylene Glycol Diethylene Glycol
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HI-DRY® Liquid Desiccant

HI-DRY, Jefferson's special grade tetraethylene glycol, will give you the *extra* dew point depression so often needed in the dehydration of higher temperature gas streams.

You may have a knotty gas treating problem that's bothering you right now. Call the helpful Jefferson man . . . Jefferson Chemical Company, Inc., 1121 Walker Avenue, P. O. Box 303, Houston 1, Texas.

Ethylene and Propylene Oxides, Glycols, Dichlorides, Carbonates • Ethanolamines
SURFONIC® Surface-Active Agents • Polyethylene and Polypropylene Glycols • Morpholine
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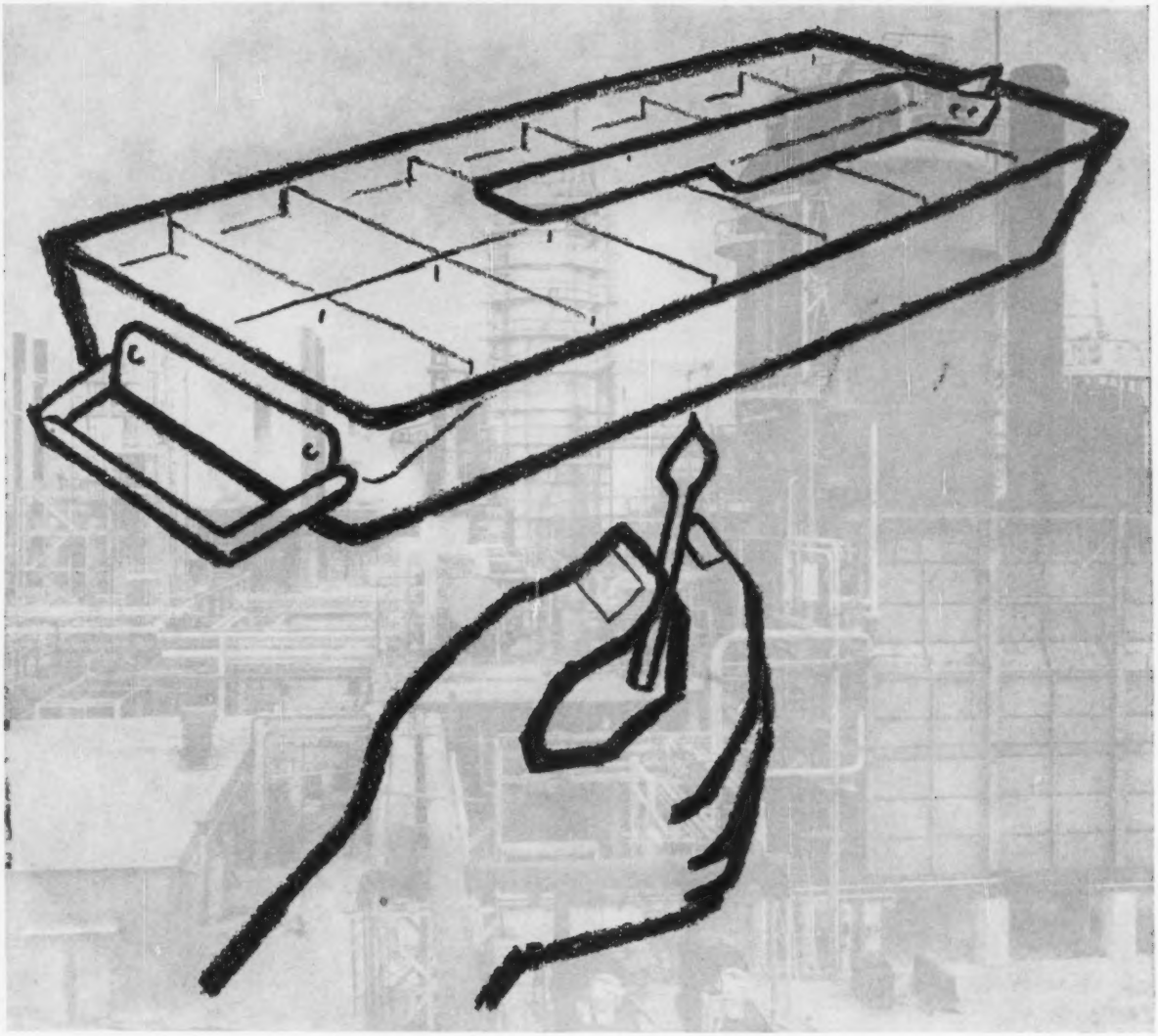
JEFFERSON CHEMICALS



RESISTS THERMAL SHOCK!

. . . another virtue of ductile iron* Stanco Valves

Numerous tests show that ductile iron, with all its other advantages, also possesses resistance to thermal shock equal to that of cast carbon steel.

Its other advantages include a metallographic structure which resists leakage or seepage by liquids or gases, so that Stanco valves made of ductile iron are *pressure tight*. Ductile iron has elevated temperature strength comparable to cast steels, and corrosion resistance equal to cast iron.

Get the complete story on the advantages that Stanco valves of ductile iron offer refinery engineers — and then check up on the savings to be made through their use!

From pattern making to testing, Stanco can help you with your valve problems, whether you need a valve from Stanco's broad line of production valves, or a special design to your specific requirements. Try us, and see!

*Trade Mark of the International Nickel Co.

STANDARD BRASS & MANUFACTURING CO.

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Fast help on corrosion control
–A big Texas natural gas plant required periodic analyses to determine whether MEA solution was breaking down in regeneration, forming corrosive salts. Samples were being sent out of state for analysis, "took forever" to get results. Enter Allied Chemical. Now tests are run in Dallas, results come back *fast*, help this plant prevent corrosion before it can start.

New plant start-up trouble quickly traced–Slug of distillate filled inlet scrubber, carried over to amine system. Aqueous amine solution thoroughly contaminated with hydrocarbon. Customer shut down plant, was going to dump entire charge. Allied Chemical specialists diagnosed trouble as too rich amine concentration, then suggested decanting solution into empty tanks, which saved half of charge.

Foaming in glycol plant–Customer wanted to know what caused it, how to stop it. Allied Chemical specialists flew to the site, deduced cause of the trouble in a matter of hours. Lab analysis confirmed their findings. In a recommendation just five typewritten lines long, they told customer how to solve the problem completely, economically.

USE GLYCOLS OR AMINES?

ALLIED CHEMICAL

technical service is ready–right now–to help you find straight answers to knotty problems

BASIC TO AMERICA'S PROGRESS

Allied Chemical

NITROGEN DIVISION
Dept. GA-5-21-4, 40 Rector Street, New York 6, N. Y.

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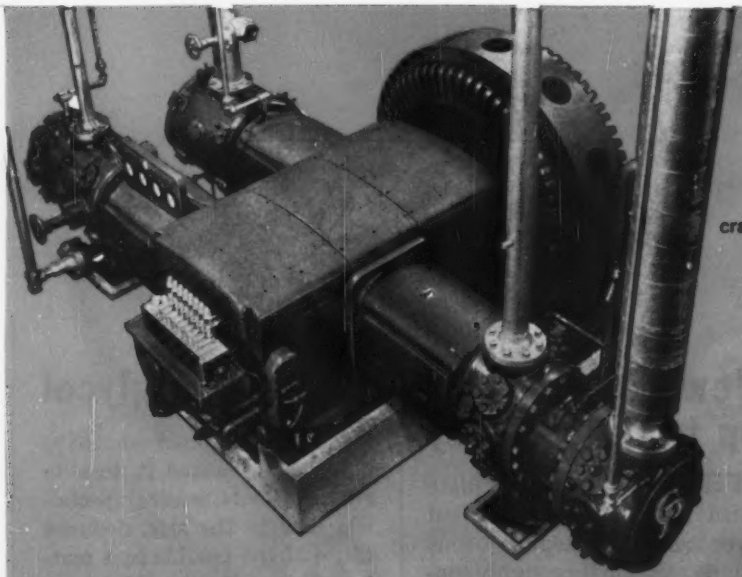
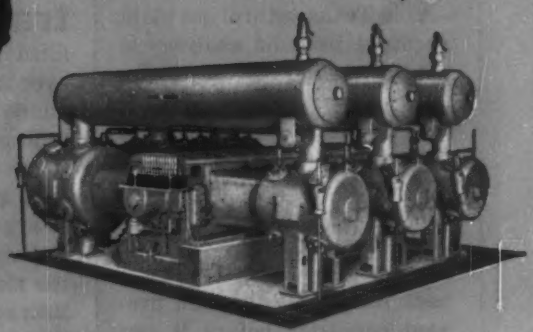
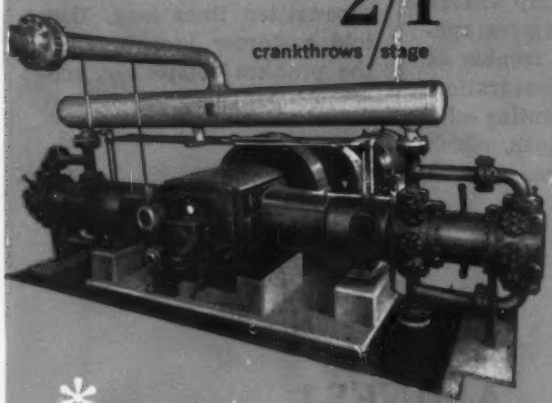


*3/3
crankthrows/stages

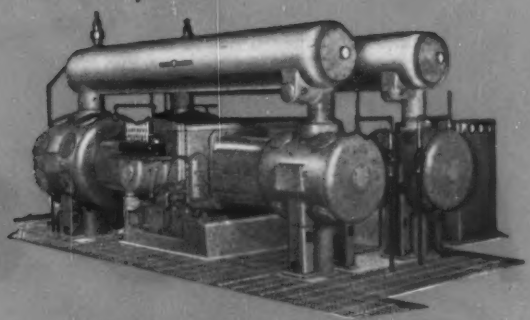
*6/2
crankthrows/stages



*2/1
crankthrows/stage



*4/2
crankthrows/stages



*Typical of the many combinations of compressor crankthrows, cylinder arrangements and staging that give you the perfect compressor for every process requirement.

ADAPTABILITY...

Chicago Pneumatic

8 East 44th Street, New York 17, N. Y.

AIR AND GAS COMPRESSORS • VACUUM PUMPS • PNEUMATIC TOOLS • ELECTRIC TOOLS • DIESEL ENGINES • ROCK DRILLS • HYDRAULIC TOOLS

- *Horsepowers to 5,000*
- *From vacuum to 15,000 psig*
- *Lubricated or non-lubricated cylinders*

at its best in CLASS FE COMPRESSORS

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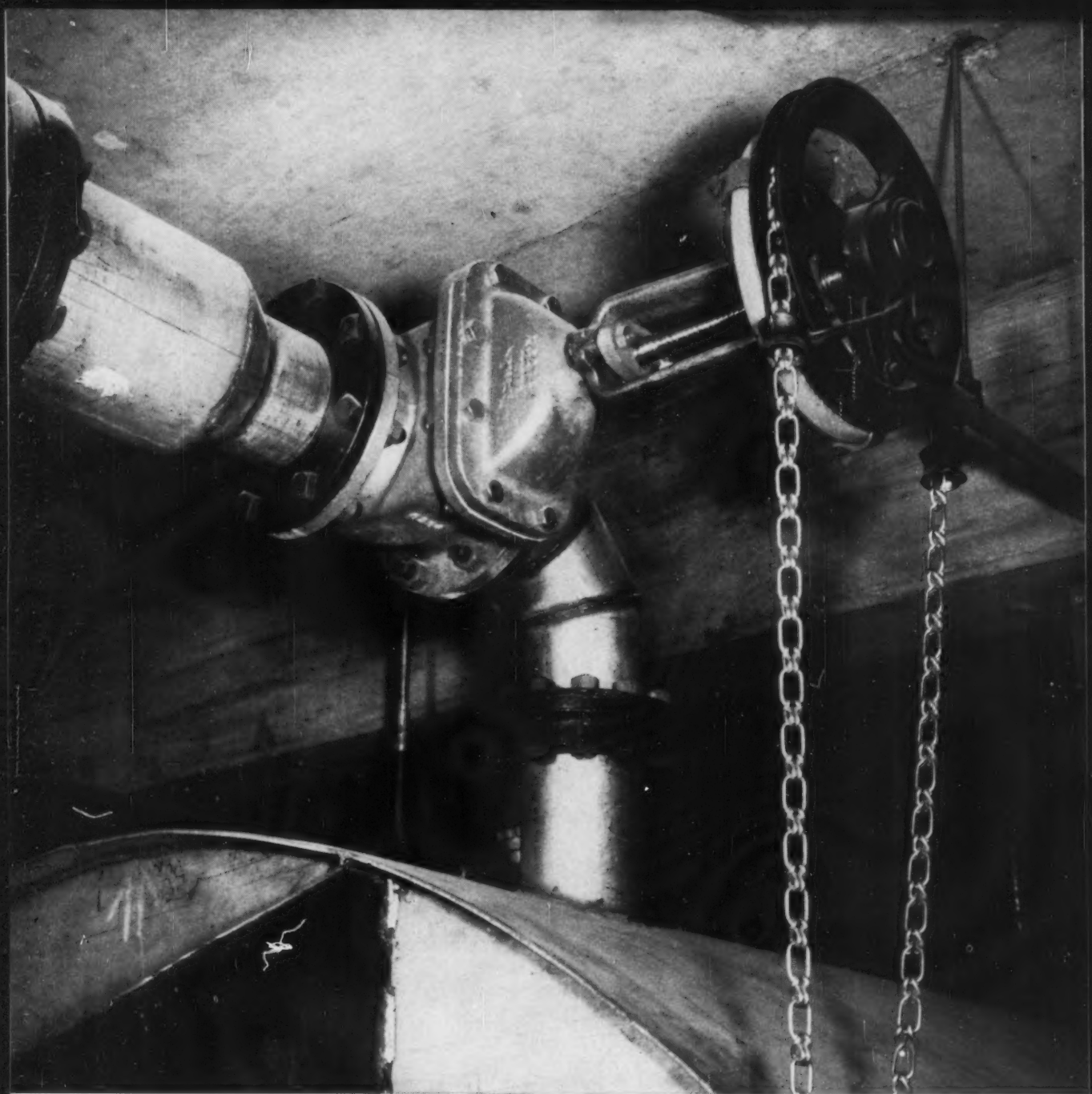

FILM GUARDIAN AT WORK... Eastman Kodak takes no chances on contamination at 1,000 acre Kodak Park in Rochester, N. Y. The 7-year-old Aloyco Stainless Steel Valve (above) helps eliminate danger from rust or contamination that could easily spoil the film base, which is later coated with a sensitive photographic emulsion. Today, thousands of industrial processes are being safeguarded by Aloyco corrosion resistant valves.

Want specific examples in your field? Our engineers will be glad to help. Just write Alloy Steel Products Company, Inc., 1303 West Elizabeth Avenue, Linden, N. J. O.1

ALLOY STEEL PRODUCTS COMPANY

Boston • New York • Wilmington • Atlanta • Birmingham • Baton Rouge • Buffalo • Pittsburgh • Chicago • St. Louis • San Francisco • Los Angeles • Seattle

SHIP 'EM

or

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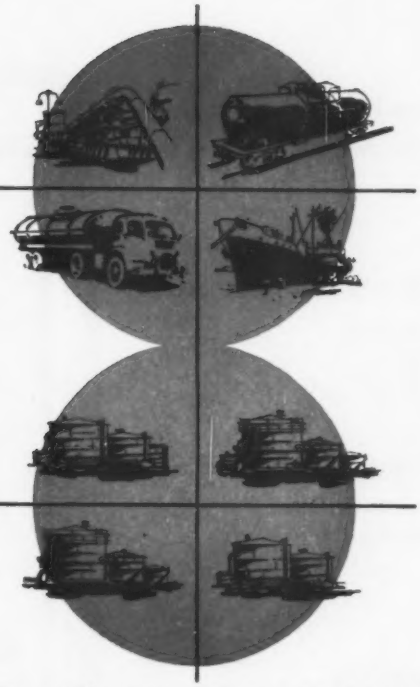

NALCO-TREATED FUEL OILS STAY FRESH!

Get rid of the hurry-up-and-sell pressure caused by unstable fuel oils that darken and sludge up when stored or shipped any distance. New Nalco 303-AC is the fuel oil dispersant-stabilizer that gives you *best* control of sludging tendencies—keeps fuel oils refinery-fresh, bright, and sludge-free even when shipped thousands of miles and stored for months.

Ask for product information on this new chemical for distillate fuels. It is available promptly from your Nalco Representative, or from Nalco direct.

National Aluminate Corporation is now

NALCO CHEMICAL COMPANY • 6259 West 66th Place, Chicago 38, Illinois

Subsidiaries in England, Italy, Mexico, Spain, Venezuela and West Germany
In Canada—Alchem Limited, Burlington, Ontario

Fuel oil at *left* is fresh from refinery, bright and clear. *Center*, Nalco-treated oil is bright and sludge-free after four months. *Right*, untreated sample in four months time has darkened considerably, already begun to sludge.

Nalco®

PRODUCTS

SERVING THE PETROLEUM INDUSTRY THROUGH PRACTICAL APPLIED SCIENCE

Nalco CHEMICALS

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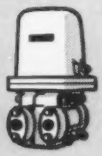
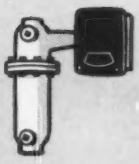
Indicating Motion-Type Transmitters
... for flow, pressure, and level



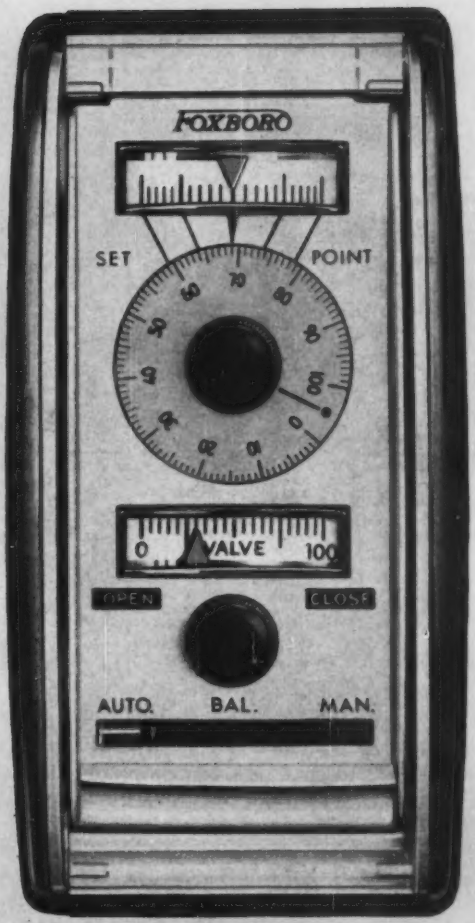
Low Displacement Force-Balance Transmitters
...for flow, pressure, and level

Thermocouple and Resistance Bulb Converters
...magnetic amplifiers...no vibrators
...no mechanical rebalancing



Displacer Level Transmitters
...force-balance for simplicity

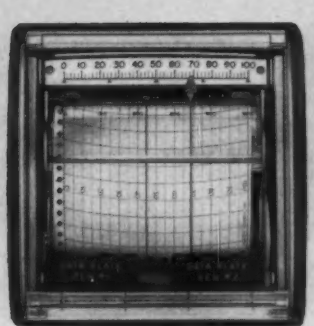
Control Valves
...electro-pneumatic and electro-hydraulic actuators



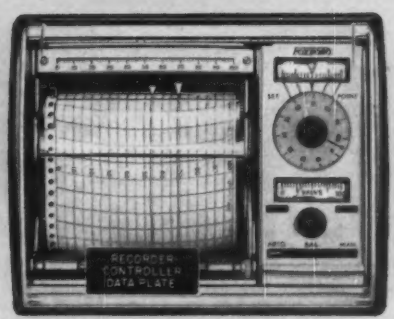
CONTROLLER
The Electronic Consotrol Controller (shown 4/5 actual size) concentrates all control and supervisory functions in one slim 3 x 6 inch case. Controller operation is entirely independent of recorder.

FOXBORO Electronic

REG. U.S. PAT. OFF.



RECORDER
Electronic Consotrol Recorders (shown ¼ actual size) use a simple, powerful pen motor which can be operated directly from transmitter signal without amplification. Available in 1 and 2 pen models.



COMBINED RECORDER-CONTROLLER
Electronic Consotrol housing design permits unequalled flexibility in panel arrangement. Recorders and controllers can be mounted separately in individual housings—or enclosed in a compound unit. Regardless of mounting, either unit pulls out independently.

for the first time... the 100% solid state electronic system!

- thermocouple and resistance bulb converters-using magnetic amplifiers
- choice of force-balance and motion-type transmitters
- long time-constant tubeless controllers

Consotrol Instrumentation

Electronic Consotrol* Instrumentation—the most complete and advanced family of electronic-operated measurement and control instruments available today! That just begins to describe Foxboro's dramatic new advance in instrumentation. ✓ ✓ ✓ Foxboro electronic transmitters, indicators, recorders, control stations, computing stations, valve actuators and other final operators cover every function in the control loop. All are linked by a d-c current signal. All are completely tubeless. Even thermocouple and resistance-type systems no longer require vacuum tubes. ✓ ✓ ✓ Electronic Consotrol systems convert temperature, pressure, flow, level, and other measurements, to a proportional signal **at the transmitter.** Transmission to a remote control station is instantaneous. Designs are available for both hazardous and non-hazardous areas. ✓ ✓ ✓ Electronic Consotrol Instrumentation heralds a whole new era in process control engineering. Write Foxboro today for the new 32-page Catalog 21-10 which gives full details. **The Foxboro Company, 742 Neponset Ave., Foxboro, Mass., U.S.A.**

*Reg. U.S. Pat. Off.

THERE IS A DIFFERENCE IN PIPE FITTINGS

CHECK THESE *Speedline*® FEATURES

THEY INSURE QUALITY . . . IMPROVE PERFORMANCE

- ✓ Uniform Wall Thickness at the Bend —in accordance with Specification MSS-SP-43
- ✓ *Every* Stainless Steel Fitting Annealed and Pickled
- ✓ *Every* Fitting marked with Size, Analysis, Schedule and Production Code
- ✓ Certified Chemical Analysis Available on *All* Fittings
- ✓ *Complete* Fitting Line — including Eccentric Reducers, Crosses, Reducing Tees, etc.
- ✓ *Full Flange Thickness*—to ASA Dimensions
- ✓ *Complete* Selection of Metals—Stainless Steel, Aluminum, Hastelloy, Titanium, Zirconium, Carpenter 20

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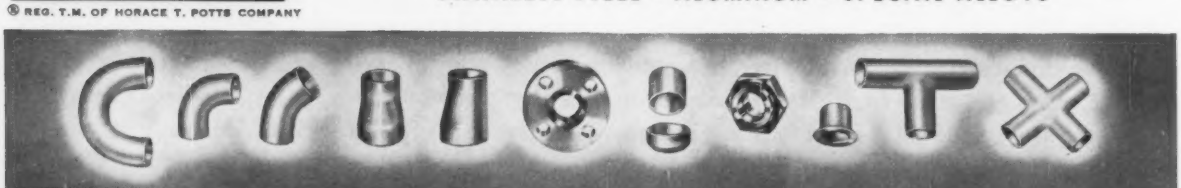

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Completes 46 Structures in 4 Months

at Petroleum Chemicals, Inc.

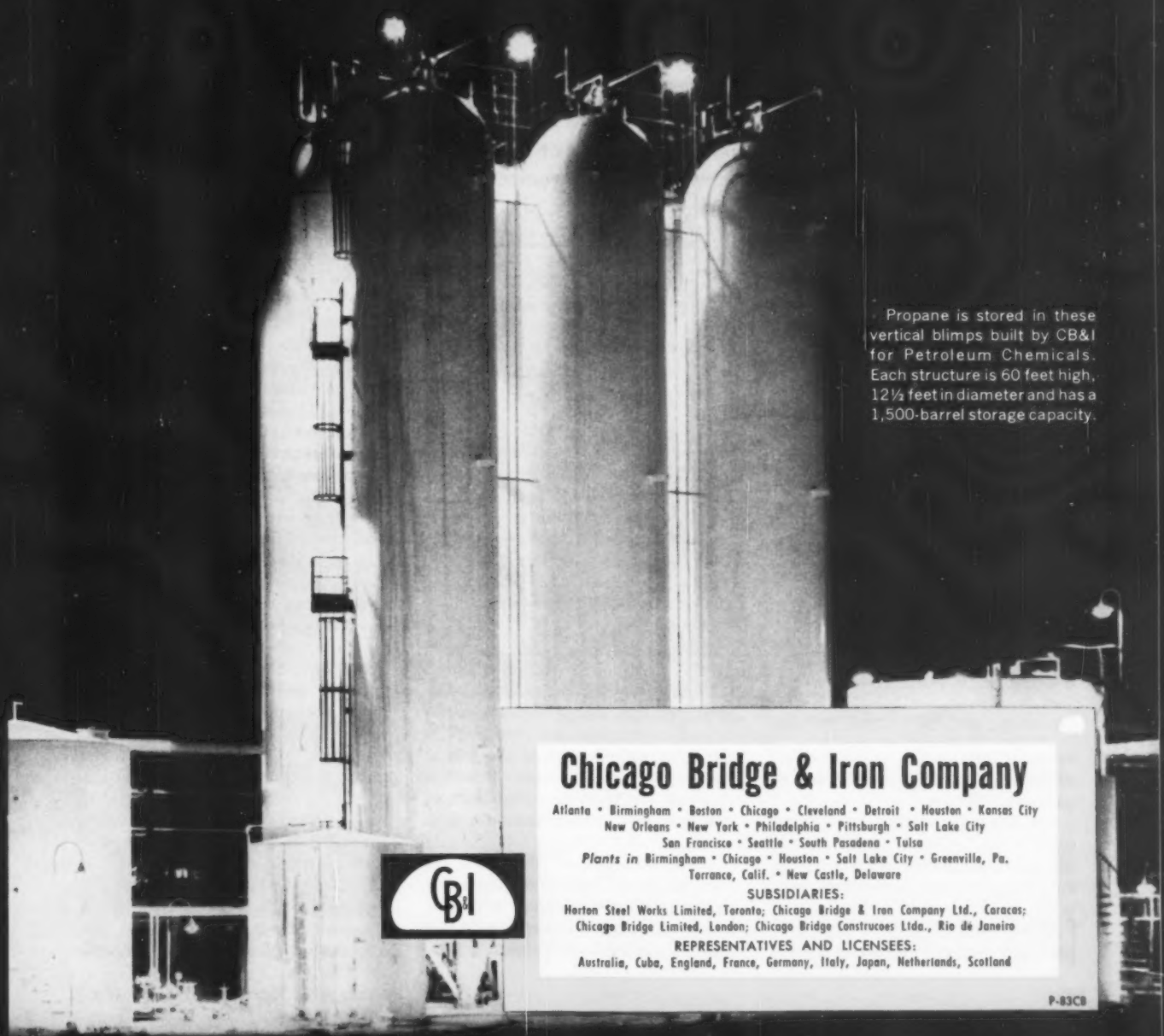
CB&I's *coordinated services* played a major role in construction of three new petrochemical plants recently placed on-stream by Petroleum Chemicals, Inc., at Lake Charles, Louisiana.

CB&I's assignment: Fabricate and erect 13 processing towers and 33 storage tanks for an expansion program that would—and did—put three plants in operation during a four-month period.

The new plants—ammonia, ethylene and ethylene oxide-glycol—have catapulted Petroleum Chemicals into a major petrochemicals producer, less than four years after its founding.

Companies on the move, such as Petroleum Chemicals, know they can depend on CB&I's *coordinated services* to meet exacting specifications and schedules. The reason: Expert, *one source* responsibility for engineering, fabrication and erection.

These are the benefits of CB&I's seven decades of *craftsmanship in steel*. Write our nearest office for the bulletin: *Development of the Oil Storage Tank*.



Propane is stored in these vertical blimps built by CB&I for Petroleum Chemicals. Each structure is 60 feet high, 12½ feet in diameter and has a 1,500-barrel storage capacity.

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HELPFUL WATER CONDITIONING DATA FROM BETZ

A MODERN APPROACH TO

The Dianodic method of corrosion control has revolutionized the treatment of open recirculating cooling water systems

Corrosion is undoubtedly the most widespread, and probably the most costly water caused difficulty that faces industry. The annual cost due to corrosion has been estimated at approximately six billion dollars. A large part of this loss occurs in cooling water systems of various types. The open recirculating cooling water system commonly used in most industries is typical. Prior to the advent of the Dianodic* method for corrosion control, chromate was the most commonly used inhibitor. Chromate concentrations in the range of 200 to 500 ppm often were employed to control corrosion. However, at this treatment level, pitting was not always adequately controlled and the cost of treatment was high.

The Dianodic method, an achievement of Betz research, was introduced approximately a decade ago, and employs a dual treatment of molecularly dehydrated phosphates and chromates over a selective pH range. This method produces effective control over pitting and tuberculation even with the relatively low treatment levels of 40-60 ppm. The superior corrosion protection secured and the low cost of treatment has encouraged wide use of the Dianodic method. Corrosion rates of 1 mil per year or less for steel are common with the pitting function completely prevented or very definitely stifled. Corrosion rates with copper and its alloys are even lower—often less than 0.3 mils per year. Figure 1 illustrates the results secured from an actual operating system.

Continued research at Betz Laboratories has permitted the development of many variations of the original Dianodic method to meet specific requirements for the individual cooling water system and to cope with the many variables that enter into the corrosion problem. The Dianodic methods include—Phosphate Dianodic — Zinc Dianodic — Fluoride Dianodic — Chromium Dianodic—as well as combinations of these methods.

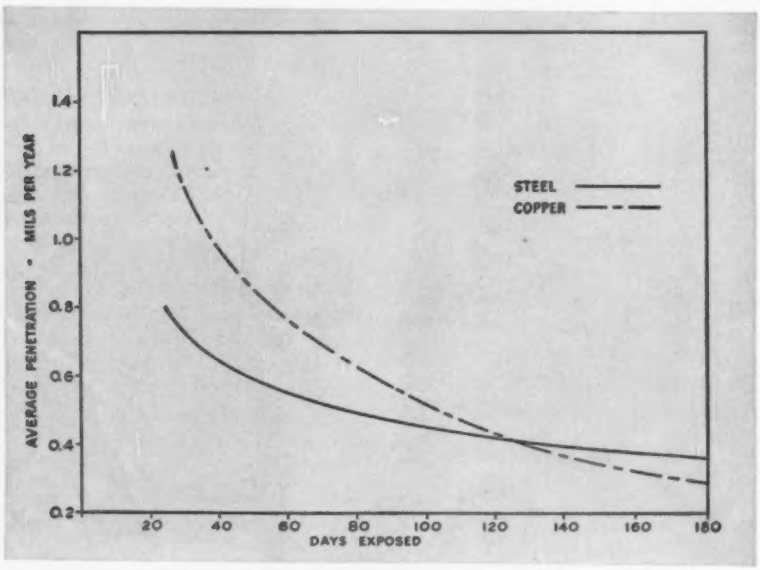

Figure 1—Corrosion results with Betz Dianodic method.

Phosphate Dianodic

The Phosphate Dianodic method which makes use of polyphosphate in combination with chromate over a controlled pH range, eliminates the pitting function that is produced by the individual components when used separately. Figures 2, 3 and 4 illustrate the control of pitting by the Dianodic method compared to phosphate and chromate when used separately. The shallow anodic areas that may develop with the use of this combination treatment have no appreciable depth and are rapidly rendered inactive. In many cases, even these shallow anodic areas do not develop.

Plant results with Phosphate Dianodic have been excellent. Treatment concentrations will vary with the individual operating conditions and may range between 30 and 100 ppm depending on water characteristics, temperature, cycles of concentration, retention time and other factors. Well established rules have been developed through years of experience over a wide range of conditions to permit the selection of the proper treatment levels, proper treatment ratios and pH range to assure maximum protection and the most economical cost for the individual system.

Zinc Dianodic

In spite of the wide coverage permitted by the Phosphate Dianodic method some limitations are encountered where calcium of the makeup water is high or the reversion of polyphosphate to the orthophosphate form is abnormal. Under these conditions it may not be possible to establish or maintain the most effective ratio of phosphate to chromate without encountering deposition of calcium phosphate. In these cases, Zinc Dianodic, another development of Betz research, can be used effectively. The superimposing of zinc on the phosphate-chromate combinations permits a greater latitude on phosphate levels or, at the same phosphate levels, improves corrosion protection. For example, when normal phosphate levels cannot be maintained due to some limiting factor, such as high calcium or a high reversion rate of the phosphate, phosphate level may be decreased and zinc superimposed. In this case, the zinc takes up the slack and acts as a cathodic inhibitor to stifle the corrosion reaction. With the introduction of Zinc Dianodic, even broader coverage is possible and this combination of zinc, phosphate and

*Dianodic is a Betz trade name. The methods are covered by U. S. Patents 2,711,391; 2,900,222; 2,872,281; 2,848,299.

chromate minimizes, if not eliminates, most limitations to use of the Dianodic method.

The Zinc Dianodic method is quite versatile and can be operated in the 'soluble range' or the 'coating range'. In the 'soluble range' or film forming range, pH and zinc values are set below the point where zinc phosphate will precipitate. Under these conditions no visible coating is formed except at points where the pH is elevated by local cell action. For example, if local cell action takes place, the area undergoing attack is the anode and the area surrounding the point of attack is the cathode. The cathodic reaction is:

$$\tfrac{1}{2}\ O_2 + H_2O + 2\ \text{electrons} = 2\ OH^-$$

The hydroxide thus formed is sufficient to elevate the pH and cause deposition of zinc phosphate which stifles the cathode reaction.

In the coating range, the zinc and pH are set above the pH of saturation of zinc phosphate which results in a coating formation over the entire system. After the desired coating is formed, the zinc and pH levels are adjusted downward so as to just maintain the coating intact and to repair the coating at any point where cell action may start. In both cases, it can be seen that the function of zinc is one of a cathodic inhibitor or barrier type treatment. Generally, however, the use of the 'coating range' is restricted to the treatment of once through systems.

In the control of corrosion, it is important that rapid film formation be accomplished to stifle the corrosion reactions. The use of Zinc Dianodic permits rapid film formation and is an excellent pretreatment for steel heat exchangers. Passivation of the steel surfaces can be accomplished in as little as two hours with treatment levels of 500 ppm or lower depending on temperature. The film thus formed can then be maintained with the normal treatment levels. Consequently, the fouling and high pressure drops that develop from the initial corrosion and tuberculation can be minimized or eliminated.

Fluoride Dianodic

Fluoride Dianodic, another development of Betz research, is designed to handle waters contaminated with aluminum. Surface supplies that are turbid must be clarified to remove suspended solids that would otherwise settle on heat transfer surfaces. It is common practice, to coagulate and settle surface supplies without the benefit of filtration when the water is used as makeup to open recirculating systems. The low turbidity from the modern type clarifier usually permits this practice. However, where aluminum is used as a coagulant and floc carryover takes place, fouling of the heat exchangers with aluminum deposits can result. Aluminum hydroxide and aluminum phosphate are most commonly encountered. The presence of aluminum interferes with the Phosphate Dianodic method by forming a soluble aluminum polyphosphate complex. The Fluoride Dianodic method makes use of the fluoride ion to preferentially complex the aluminum ion. The soluble complex thus formed acts dianodically with chromate and aids in avoiding fouling and stifling of corrosion.

Chromium Dianodic

The original applications of Phosphate Dianodic to many refinery cooling water systems uncovered many incidences where leakage from the process side was taking place. Where sour crudes are being processed, the leakage contaminates the cooling water with hydrogen sulfide, mercaptans and organic matter. Formerly, such leakage went undetected for appreciable periods of time and usually was discovered only after extensive damage was done to the system. With the application of Dianodic, the chromate component of the treatment is reduced by these contaminants to trivalent chromium and leakage is readily detected. Where possible the leakage should be corrected immediately to minimize the heavy corrosion load imparted by hydrogen sulfide. In many cases, immediate correction of the leakage is not possible and a suitable method of treatment in the presence of process leakage becomes necessary. This led to the development of Chromium Dianodic which makes use of chromium phosphate as a barrier type treatment during periods of leakage.

COOLING WATER TREATMENT

Figure 2—Chromate pits at 18 magnifications.

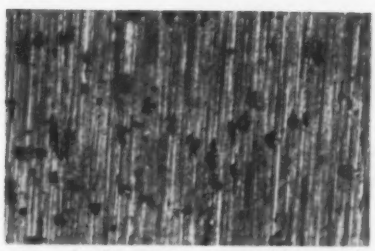

Figure 3—Phosphate pits at 18 magnifications.

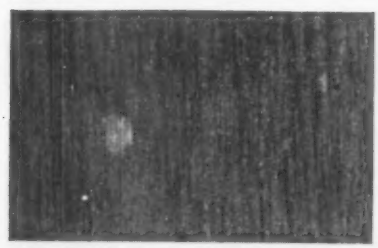

Figure 4—Shallow anodic areas from the Dianodic method at 18 magnifications.

The Betz Dianodic methods are the most effective for open recirculating cooling water systems. Competitive studies have demonstrated this fact conclusively. The versatility of these methods makes them suitable for overcoming corrosion problems in practically every cooling water system—effectively and economically. A Betz Field Engineer will be pleased to discuss your cooling water problems and acquaint you with the savings that can be accomplished by the use of Betz Dianodic methods. A good time to call him in is *today!*

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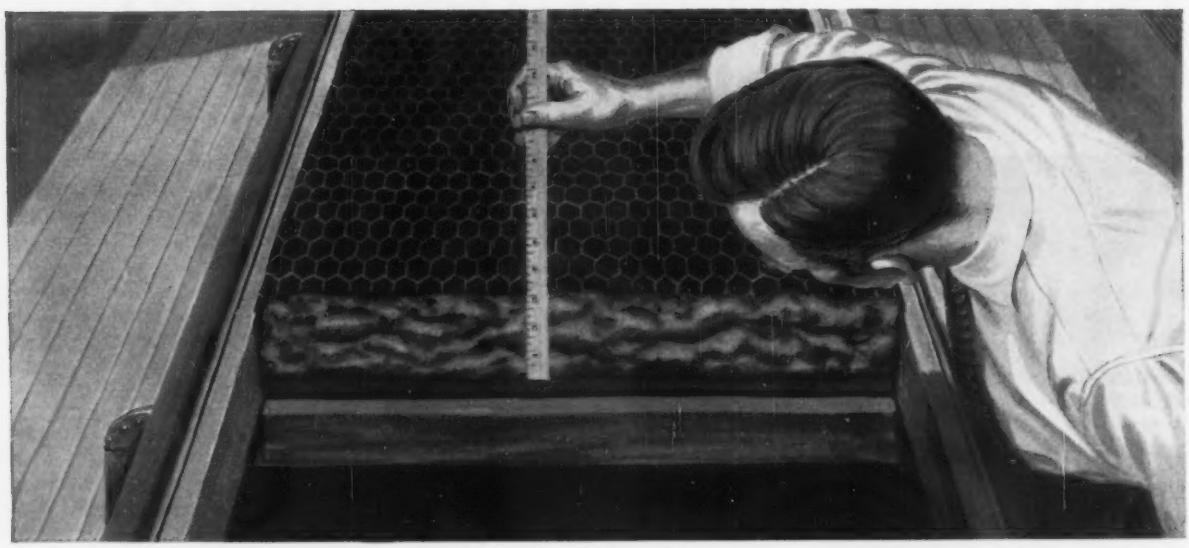
CONSULTANTS ON INDUSTRIAL WATER PROBLEMS

FACTORY FABRICATED TO RIGID SPECIFICATIONS!



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Make speedier checks of recorders, controllers and base or noble metal thermocouples in industrial plants with the new three-dial 8686 Portable Millivolt Potentiometer. Features such as a central reading window . . . where measured values appear as a row of digits with a scale interpolation . . . simplify calibration of thermocouples and test measurements. The 8686 Potentiometer has: a wide operating range of −10.0 to +100.1 mv and +1010 to +1020 mv for standard cell calibration; and a high accuracy of ±(0.05% of reading +3μv) without reference junction compensation, ±(0.05% of reading + 6 μv) with ref. jct. comp. Write for Data Sheet E-33(1A).

8686 Millivolt Potentiometer

8690 Millivolt Potentiometer

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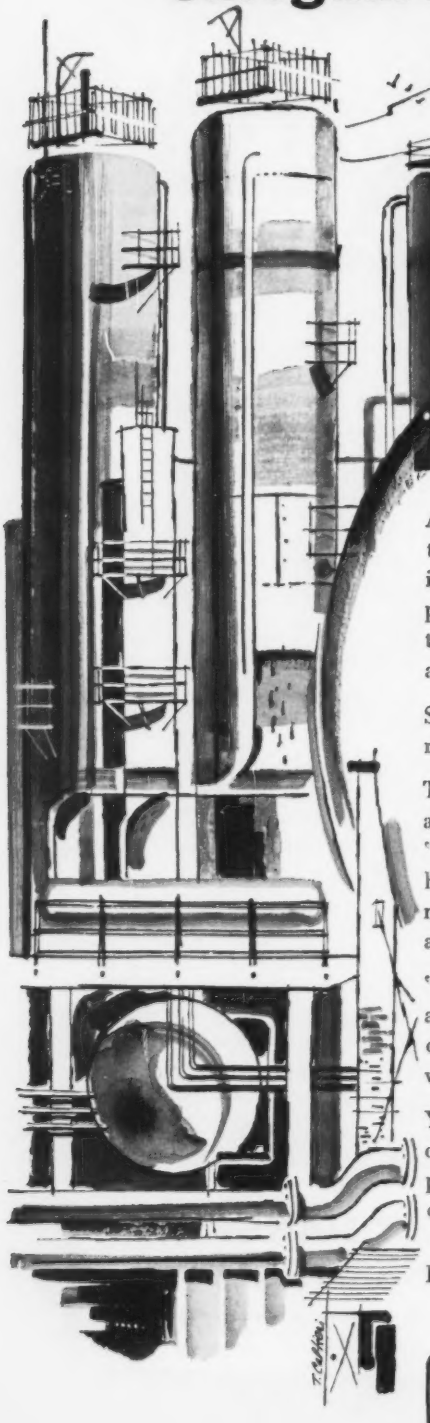
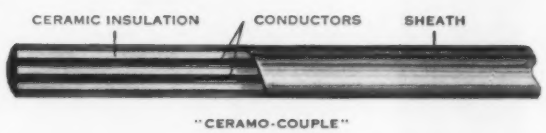
1,000 Ceramo® Thermocouples Safeguard New Multi-Million Dollar Petrochemical Complex





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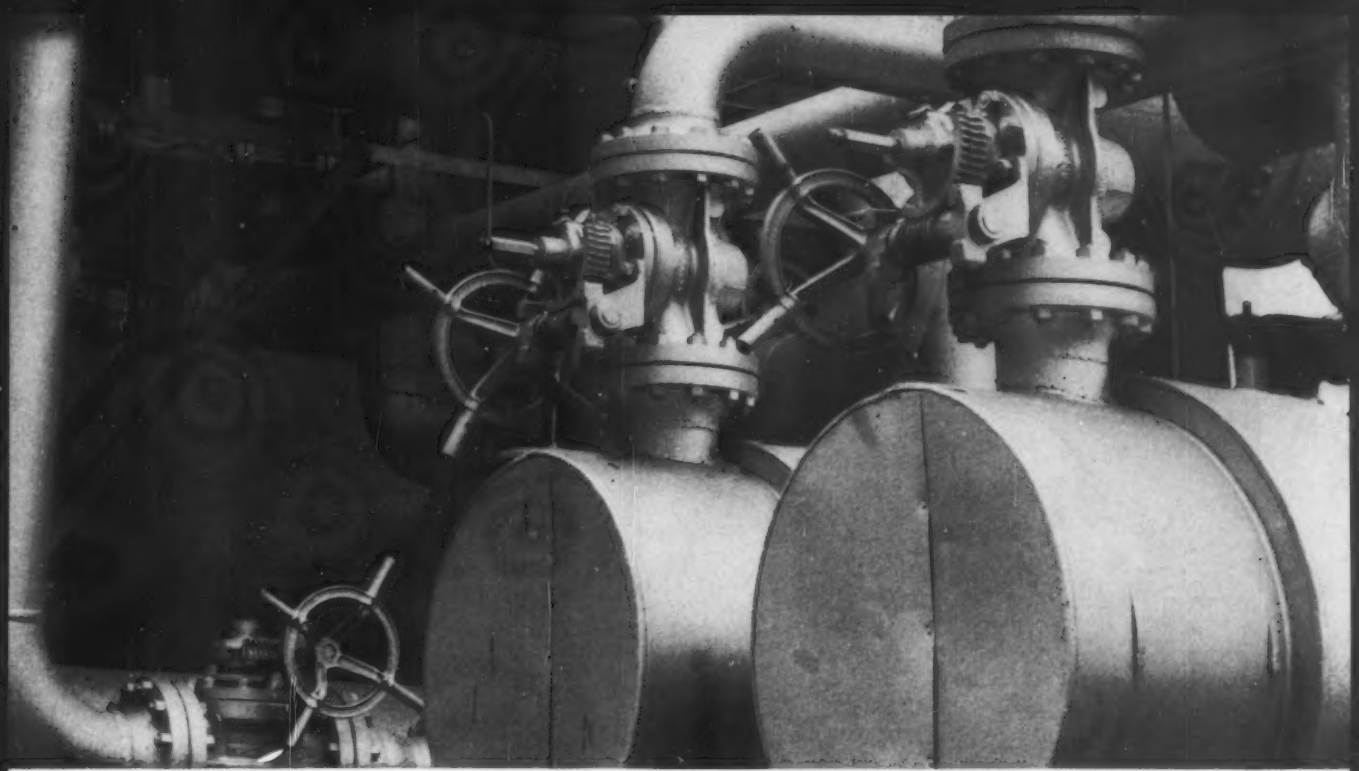

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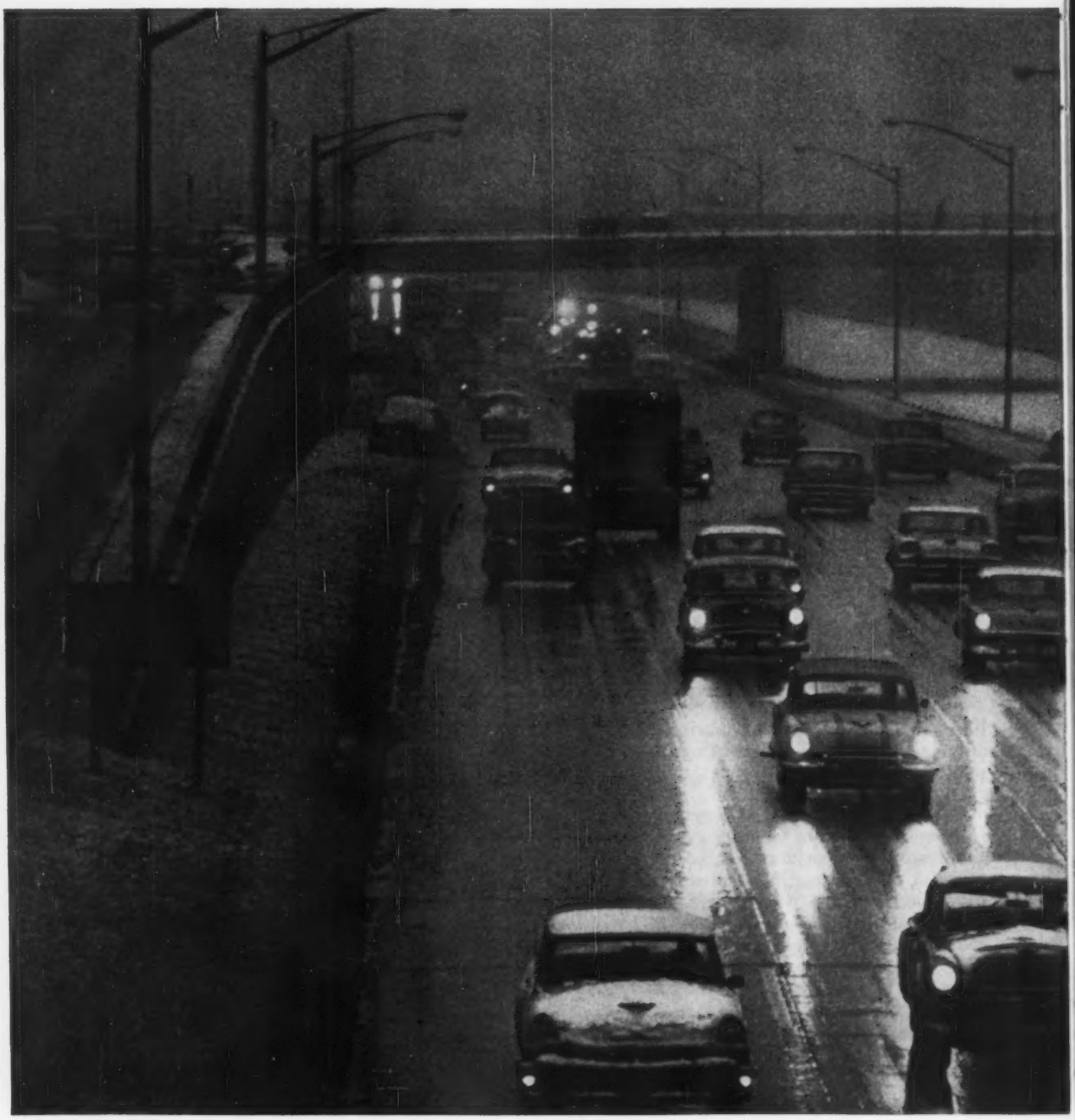

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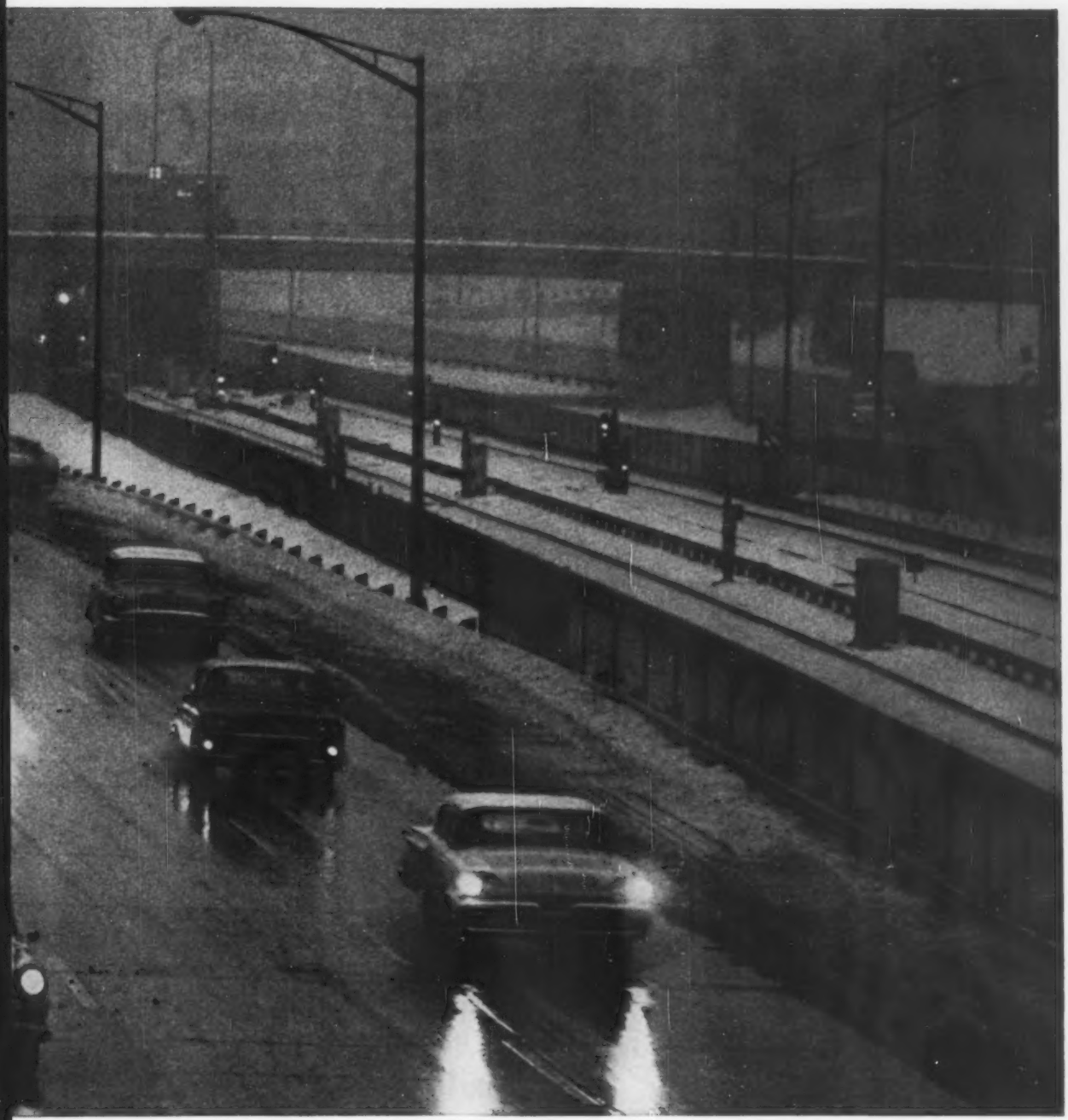

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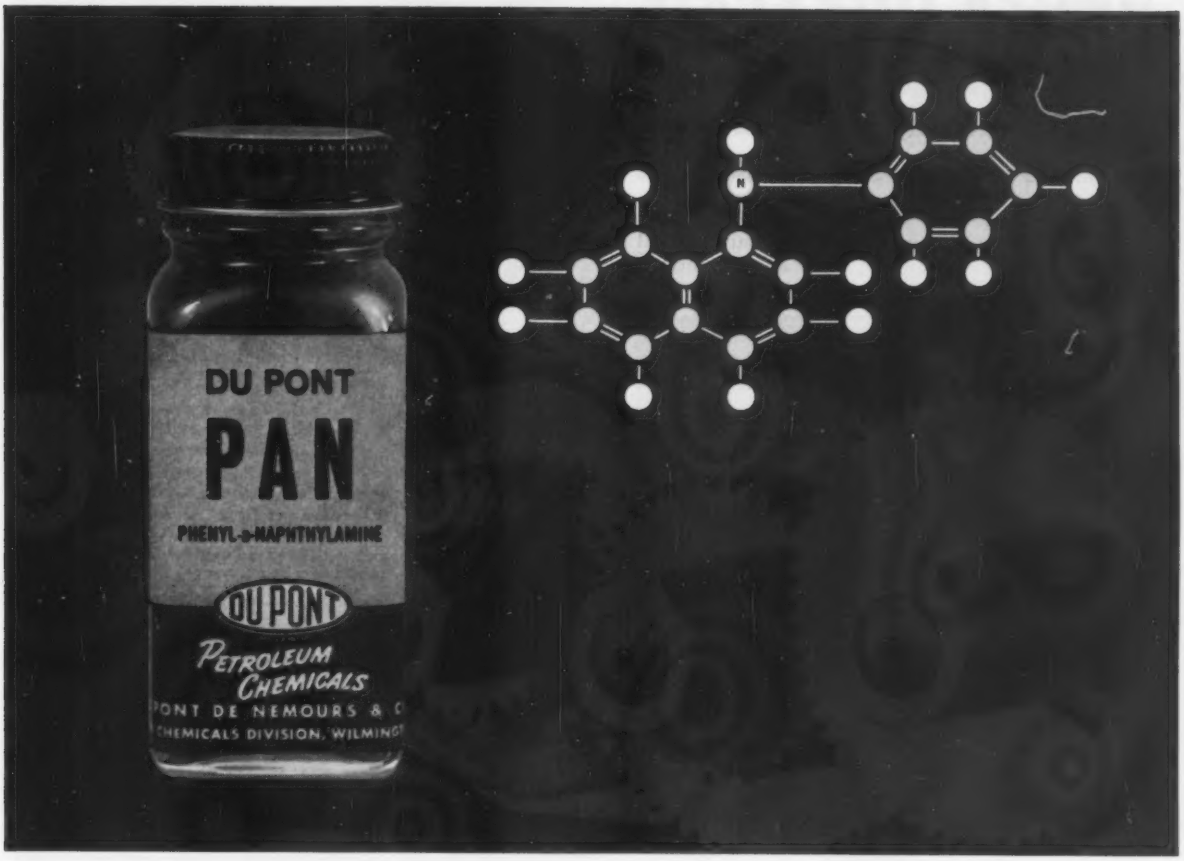

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SUPER-POWERED
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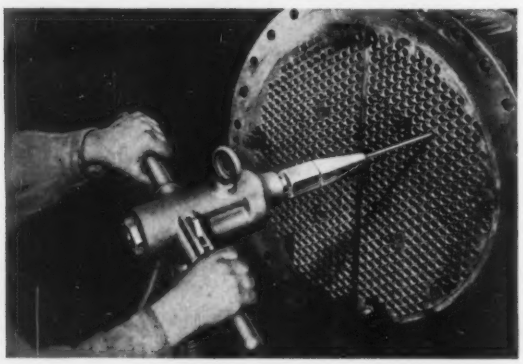
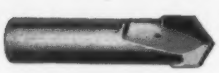


For heavy duty service, for example, use Wilson air driven Model TP 301 shown above. This super-powerful, 15 lb, light weight, scavenger-type tube cleaner drills and simultaneously flushes out deposits. It is suitable for vertical or horizontal use in straight tubes 3/8" ID to 2 7/8" ID and up to 40' long. Cleans rapidly and thoroughly, operating at high speed at 90 psi. Can run on pressure as low as 50 psi. Other Wilson Cleaners are available for every tube size.

WILSON SUPER-DUTY CARBIDE BITS



TYPE M BIT
An inserted two-lip Helix type for general use.
11/32" to 1 19/32" bit OD.

TYPE K BIT
A two-lip Helix type with adaptor for general use.
1 1/4" to 2 3/4" bit OD.

TUBE EXPANDERS— Wilson Models 41 and 44 Self-Feeding Tube Expanders are modern tube expanders for the *precision rolling* of condenser and heat exchanger tubes into heavy tube sheets. Ball Bearing Collar Type 1/2" OD to 2 1/2" OD • **Write for your free copy of Wilson Catalog 77-88. It's a mine of information on tube cleaning and tube expanding problems.**

Representatives in principal cities
THOMAS C. WILSON, INC.
21-11 44th Ave., Long Island City 1, N.Y.
Cable Address: "Tubeclean," New York

WILSON
TW-899
BETTER TOOLS FOR BETTER WORK

Babbitt *Adjustable* SPROCKET RIM
with Chain Guide
CHANGES THAT DANGER ZONE TO A SAFETY ZONE

The distance between the floor of your plant and your overhead valves is a DANGER ZONE when piled up boxes or even ladders are used to reach the valves.
Turn it into a SAFETY ZONE — equip your overhead valves with Babbitt Adjustable Sprocket Rims with Chain Guides.

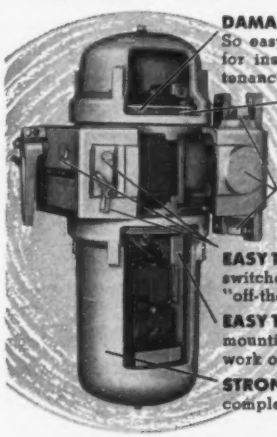
- They simplify pipe layout.
- They fit any size valve wheel.
- They are easy to install and operate.
- They operate any valve from the floor.
- They save time and money.
- The first cost is the only cost (no maintenance).
- They are packed completely assembled (one to a carton), with easy-to-follow instructions.
- A hot-galvanized rust proof chain is available for all sizes.

Babbitt Adjustable Sprocket Rims with Chain Guide are carried in stock by most mill supply houses. If your supplier does not carry them, contact us direct.

Babbitt STEAM SPECIALTY CO.
6 BABBITT SQUARE, NEW BEDFORD, MASS., U.S.A.

NEW SPIN TOP® ENCLOSURE FOR HAZARDOUS LOCATIONS

4 SIZES for Starters 0 thru 5
CLASS I, GROUP C and D • CLASS II, GROUP E, F, and G



DAMAGE-RESISTING Acme thread. So easy to put on and take off tanks for installation, inspection or maintenance.

REAL PROTECTION against rain, dust, dirt and weather because male threads on collar section engage female threads on tank.

INCREASED WIRING SPACE and through-feed conduit entrances for horizontal tap-offs.

EASY TO ADD pushbuttons or selector switches with easy-to-buy, easy-to-use, "off-the-shelf" parts kits.

EASY TO INSTALL • "Slide and Hook" mounting arrangement takes the hard work out of the installation job.

STRONG and LIGHTWEIGHT • The complete enclosure is cast aluminum.

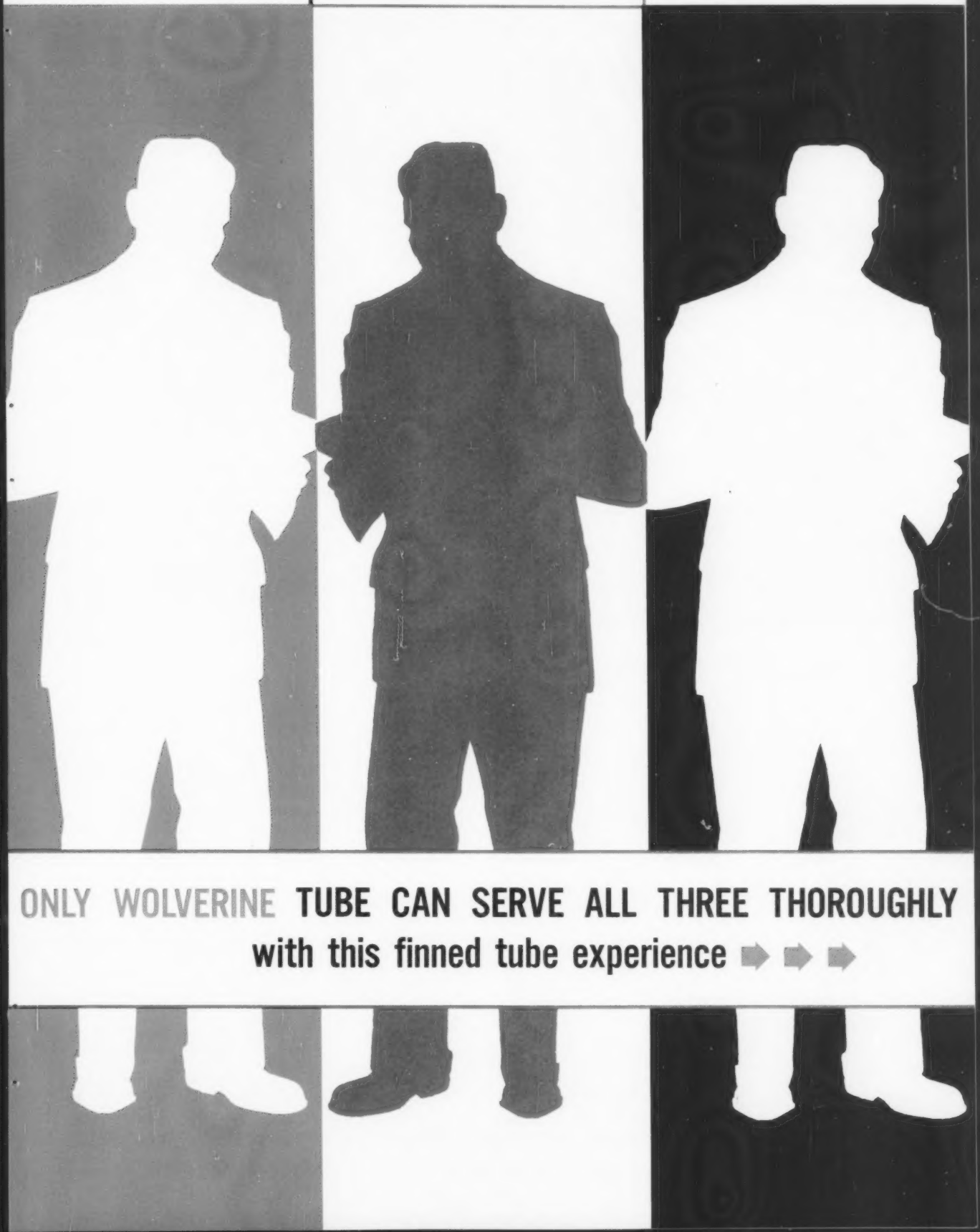
Write for **BULLETIN 9990. Square D Company, 4041 North Richards St., Milwaukee 12, Wis.**

SQUARE D COMPANY
wherever electricity is distributed and controlled

PROCESSING INDUSTRIES

HEAT EXCHANGER FABRICATORS

ENGINEERING AND CONSTRUCTION



ONLY WOLVERINE **TUBE CAN SERVE ALL THREE THOROUGHLY**
with this finned tube experience ➡ ➡ ➡

THERE'S NO BETTER BUY THAN COMPLETE SERVICE

PRODUCTS

Wolverine Trufin®—the integrally finned condenser tube is available in a wide choice of metals, alloys and sizes in Types H/A, H/R, I/L, L/C, S/T. These various tubing types differ in fin heights and fin spacings. Duplex tubes with inner and outer tubes of different metals are available in types S/T and L/C. They are also available with four distinct types of end treatments. Wolverine also manufactures prime surface condenser tube in a wide range of sizes and alloys.

FIELD ENGINEERING SERVICE

For the benefit of its customers Wolverine's Field Engineering Service is staffed with tubing specialists who have specialized training in tubing, alloys and metallurgy, equipment design, heat transfer, etc. When you require heat transfer consultation, Wolverine has available a number of heat transfer specialists home based in the country's major processing areas. Their services are yours—without obligation.

FACILITIES

In addition to two tube manufacturing plants Wolverine also maintains a network of sales offices across the United States. Wolverine's Detroit, Michigan plant recently underwent a multimillion dollar modernization program that makes it one of the most modern tube mills in the United States. Its Decatur, Alabama plant, more than ¼-mile in length, is equally modern — is equipped with the finest machinery available.

We'd very much like your next tubing order. We're equally very sure you'll like our tubing and services. A telephone call to the nearest Wolverine Sales Office (we're in the Yellow pages) will start things rolling. May we hear from you soon?

CALUMET & HECLA, INC.
CALUMET DIVISION
URANIUM DIVISION
GOODMAN LUMBER DIVISION
WOLVERINE TUBE DIVISION

In Canada:
CALUMET & HECLA OF CANADA LIMITED
WOLVERINE TUBE DIVISION
CANADA VULCANIZER & EQUIPMENT CO., LTD.
UNIFIN TUBE DIVISION

WOLVERINE TUBE
DIVISION OF
CALUMET & HECLA, INC.
17236 Southfield Road
Allen Park, Michigan
Manufacturers of Quality Controlled Tubing and Extruded Aluminum Shapes

PLANTS IN DETROIT, MICHIGAN AND DECATUR, ALABAMA.
SALES OFFICES IN PRINCIPAL CITIES

HIGH PERFORMANCE at LOW COST

NEW "Varec" Fig. 2000 SERIES VENT VALVE

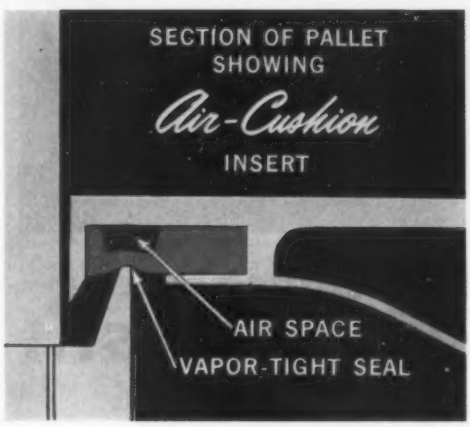


FIG. NO. 2000-81 PRESSURE-VACUUM VENT VALVE

"Varec" has a new Vent Valve with a feature that is going to make contemporary vent valves outdated! It's the unique new "Air Cushion" insert in the pallets.*

The "Air Cushion" forms a perfect air-tight seal with the anodized seat ring. Anodizing prevents corrosion. The insert is made of a special compound of synthetic rubber, which resists freezing. It is flexible yet durable, providing long service with minimum maintenance. Inserts are easily replaced.

A 20% cut in weight makes this new "Varec" Vent safe for mounting on lightest gauge tanks. Installation is made easier and in many cases special rigging is unnecessary.

Increased flow capacity has been developed by a new flared, sturdy, spun-type aluminum hood.

"Blow down" is scientifically controlled, insuring greater vapor conservation than diaphragm type valves.

This "Varec" Fig. 2000 Series Vent Valve incorporates all the latest improvements and refinements in design, yet with all its quality, efficiency and low maintenance expense . . . it costs you less. It will pay you to get full details . . . ask for Catalog Page 2-0.1.

*Pliable solid type rubber inserts only in 2", 3", 4" sizes and high pressure settings.

"Varec"
TRADE ® MARK
JAPAN NO. 539648

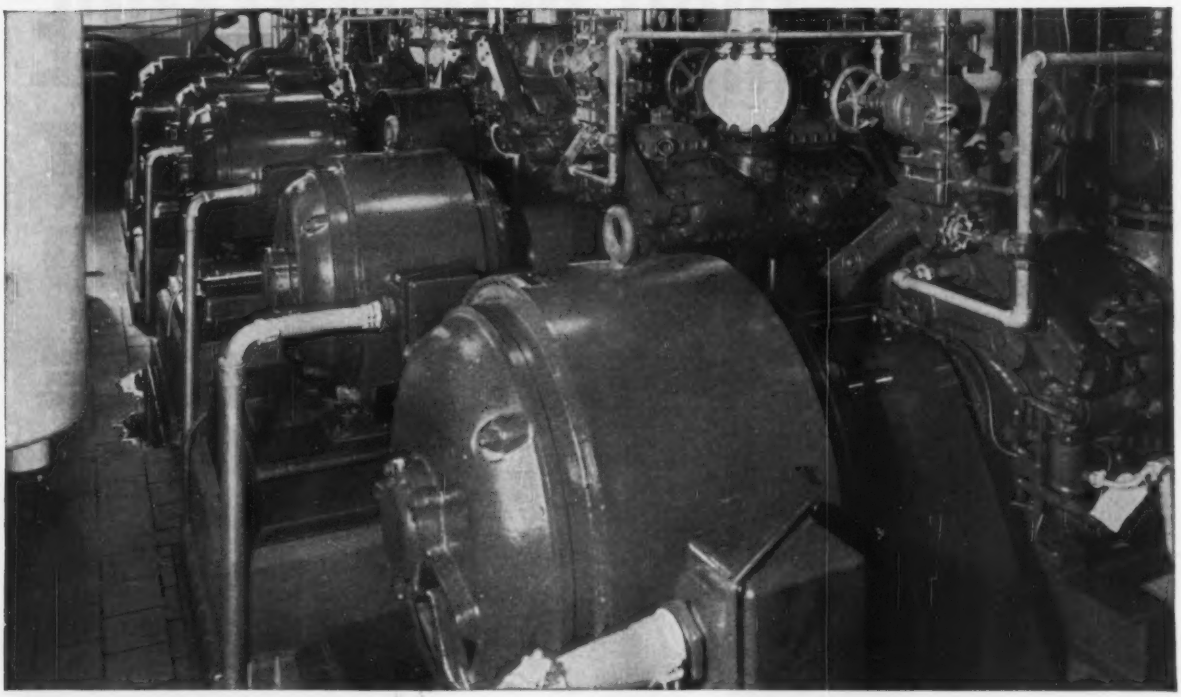
THE VAPOR RECOVERY SYSTEMS COMPANY

P-8

© 1960

"VAREC", 2820 NORTH ALAMEDA STREET, COMPTON, CALIFORNIA. *Branches and Representatives in Principal Cities.*

WAGNER ELECTRIC MOTORS . . . THE CHOICE OF LEADERS IN INDUSTRY



End Voltage Drop and Line Disturbance Problems caused by starting ***BIG MOTORS . . .***

Type RP polyphase motor in ratings to 500 hp with increment type starter.

Use Wagner Increment Motor-Starter Combinations

Increment starting is the easy, inexpensive way to limit the inrush of starting current in motors up to 500 horsepower. And, you do it *best* with Wagner Increment Motor-Starter Combinations . . . polyphase open-type, totally-enclosed, or explosion-proof motors and magnetic increment starters.

Line disturbances are reduced because current taken from the line is not broken during the starting period. Motors start sure and fast . . . reach full speed in a matter of seconds. And . . . Wagner combinations cost less than motors with primary resistance or auto-transformer type starters.

Two more plusses: The compact, relatively lightweight starter is easy to connect . . . needs very little attention. The motor requires only regular inspection, cleaning, and lubrication . . . maintenance is minimized.

While 2-step combinations are suitable for most applications . . . 3, 4, 5, or 6-step increment motor-starter combinations are available for installations where unusually low inrush of starting current is required. All meet the polyphase motor-starting requirements of AEIC-EEI-NEMA.

It's possible you can save money on your big jobs with Wagner Increment Motor-Starter Combinations. A Wagner Sales Engineer will help you. Call the nearest Wagner branch or write us for Bulletins MU-128 and MU-195.

BRANCHES AND DISTRIBUTORS IN ALL PRINCIPAL CITIES

Wagner Electric Corporation

6458 PLYMOUTH AVENUE, ST. LOUIS 33, MISSOURI

WH60-1A

ELECTRIC MOTORS • TRANSFORMERS • INDUSTRIAL BRAKES • AUTOMOTIVE BRAKE SYSTEMS—AIR AND HYDRAULIC

DEKORON ARMORED INSTRUMENT HARNESS

4 + 4 = 16

TUBE MATERIALS + TUBE CONSTRUCTIONS = DIFFERENT TYPES

Yes, *four* different core tubing materials (copper, aluminum, polyethylene, nylon) combined with *four* distinct types of armoring give you *sixteen* different types of Dekoron Armored Instrument Harness from which to choose.

Designed specifically for instrument harness application, special Moore-Loc armor construction has almost twice the pull-apart resistance of ordinary armoring . . . has cord packing for extra resistance to moisture and fume penetration.

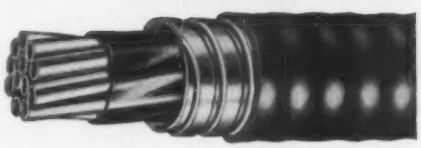
There's at least one best type of Dekoron for your installation. We help *you* select it; we're unbiased because we make all types. Now go Dekoron 100% for all your tubing needs. Think of Dekoron first . . . to last. That's *Dekoron—America's Premier Line of Armored Instrument Harness.* A-314A

CONSTRUCTIONS

TYPE VA

For Impact and Corrosion Resistance. Core tubes with vinyl sheath covered with Moore-Loc modified-square-lock construction armor with cord packing.

TYPE VAV



For Impact and Maximum Corrosion Resistance. Same construction as Type VA (*above*) but with outer vinyl sheath. 24-gauge galvanized steel armor gives maximum pull-apart and impact resistance.

TYPE A

For Impact Resistance in Dry Locations. Core tubes are wrapped in vinyl-impregnated insulating tape. Tape insulates and cushions core tubes inside metal armor.

TYPE AV

For Corrosion and Impact Resistance. Same construction as Type A (*above*) but with outer vinyl sheath. All four constructions available with metal or plastic core tubes.

Dekoron® products QUALITY • RESEARCH • SERVICE

SAMUEL MOORE & COMPANY

DEKORON PRODUCTS DIVISION • MANTUA, OHIO

For more data on advertised products, use Readers' Service Cards, last page.

Report from Tidewater...

How Cooper-Bessemer hydrogen boosters supply 800 psi 'round-the-clock

At Tidewater Oil Company's refinery south of Wilmington, Delaware, two Cooper-Bessemer FM-2 compressors play a vital part in the hydrogen treatment process by which the refinery upgrades a number of products and intermediate fractions. The giant refinery operates 24 hours per day, boosting 690 cfm of hydrogen at 470 psi to a discharge of 800 psi. This hydrogen is delivered directly to the desulfurizers.

These Cooper-Bessemer compressors have performed well under this heavy-duty service. Maintenance costs and outage time have been low.

The customer is also pleased with the performance of three Cooper-Bessemer air compressors which supply utility air to the entire refinery on a 24-hour, 365-day per year basis.

Find out how Cooper-Bessemer products can help assure dependable compression and optimum economy for *your* processing. Call our nearest office for help in planning of your facilities.

BRANCH OFFICES: Grove City • New York • Washington Gloucester • Pittsburgh • Chicago • Minneapolis • St. Louis Kansas City • Tulsa • New Orleans • Shreveport • Houston Greggton • Dallas • Odessa • Pampa • Casper • Seattle San Francisco • Los Angeles

SUBSIDIARIES: Cooper-Bessemer of Canada, Ltd.... Edmonton Calgary • Toronto • Halifax

C-B Southern, Inc.... Houston

Cooper-Bessemer International Corp.... New York • Caracas • Anaco

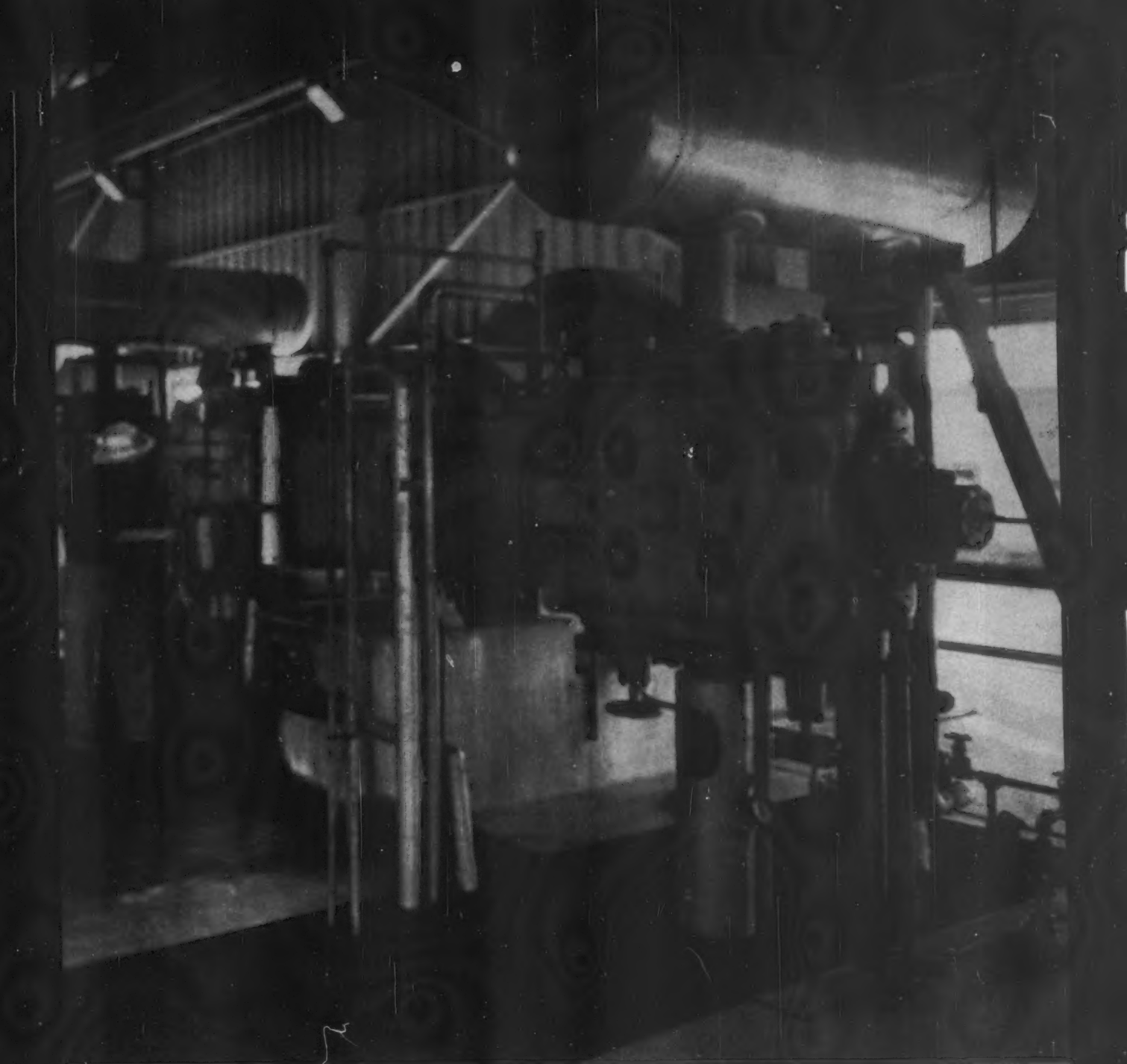
Cooper-Bessemer, S.A.... Chur, Switzerland • The Hague, Netherlands • Mexico City

The Rotor Tool Company... Cleveland

Cooper Bessemer

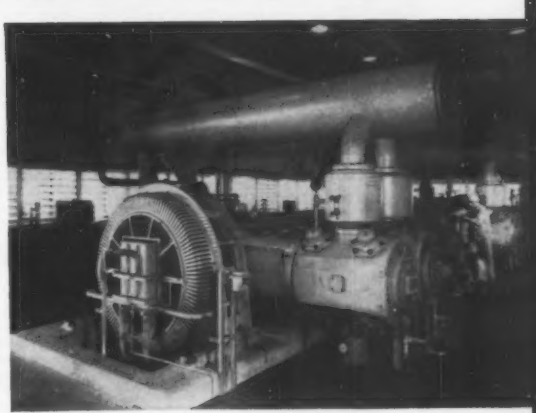
GENERAL OFFICES: MOUNT VERNON, OHIO

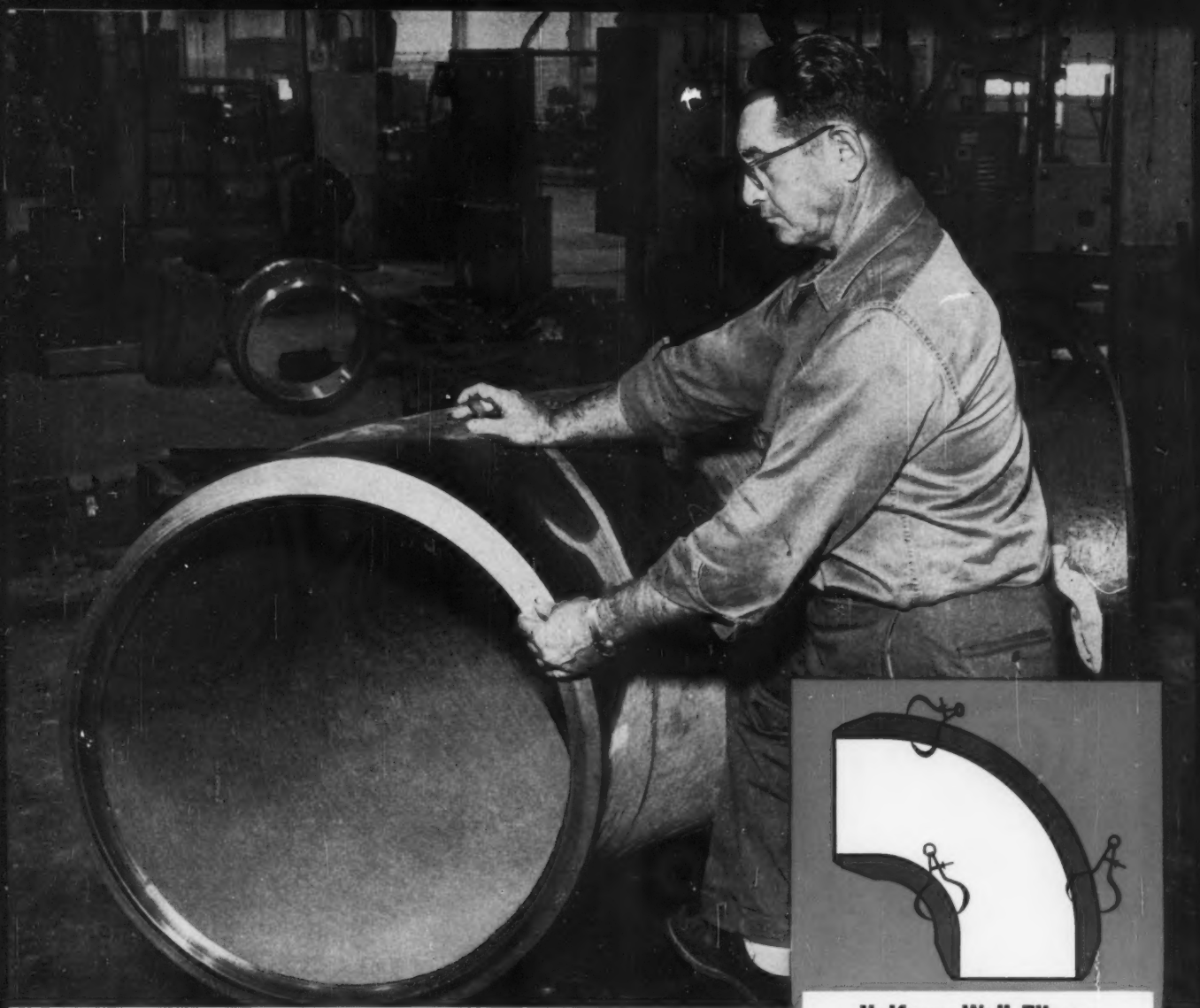
ENGINES: GAS - DIESEL - GAS-DIESEL
COMPRESSORS: RECIPROCATING AND CENTRIFUGAL, ENGINE, TURBINE OR MOTOR DRIVEN



Cooper-Bessemer FM-2 Hydrogen Compressors at Tidewater Refinery. Rated 690 cfm, suction 470 psi, discharge 800 psi.

Three Cooper-Bessemer Air Compressors at Tidewater. They supply utility air at about 120 psi for processes throughout the refinery.





KEY-KAST® Long Tangent Elbows provide uniform strength

KEY-KAST *Long Tangent* Welding Elbows will give you outstanding service in any high pressure, high temperature alloy piping system. They are the *only* long tangent elbows with cast steel walls of uniform thickness and strength. Nipples and extra welding are eliminated — long tangents can be provided at either or both ends.

Quality controlled through the most rigid metallurgical standards, Key-Kast Elbows meet ASTM specifications, and ASME and ASA code requirements.

Call your Key-Kast representative for prompt, experienced service in selecting the Key-Kast *Long Tangent* Elbow best for you. Available in all standard sizes and schedules with tangent lengths as long as half the O.D. of the connecting pipe . . . and specially designed to meet specific conditions of pressure, temperature and lading.

Products of W-K-M's *Creative Engineering*

W-K-M

DIVISION OF ACF INDUSTRIES
INCORPORATED
P. O. BOX 2117, HOUSTON, TEXAS

Uniform Wall Elbows

Key-Kast **Long Tangent** Elbows have uniform cast steel walls approximately 15% heavier than the required minimum thickness of pipe walls of the same I.D. For extra highly stressed line sections, the wall thickness can be increased as much as desired — without sacrificing uniformity.

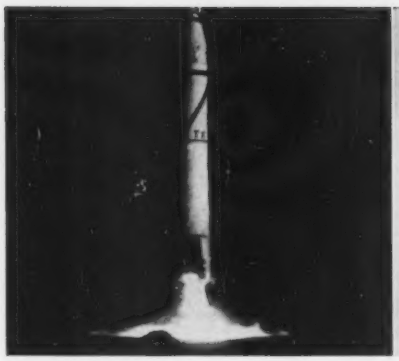
The flexibility of Key-Kast Elbows permits their use in piping systems based on the usual piping stress calculations. Write for engineering bulletin entitled "Key-Kast Welding Elbows in Piping Stress Calculations," for W-K-M's Quality Control Specifications No. 102958 (conventional steam power) and No. 103058 (nuclear power).

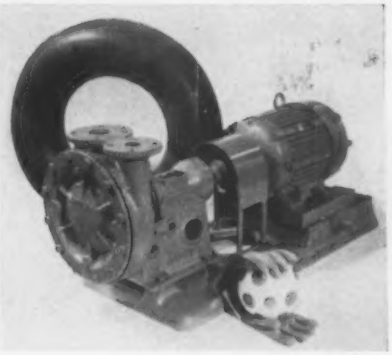
Key-Kast Fittings can handle **any** piping job. Specify them. You'll get outstanding service.

5903-R

PUMPAGE

Goulds news about pumps for process industries





Rocket's red roar

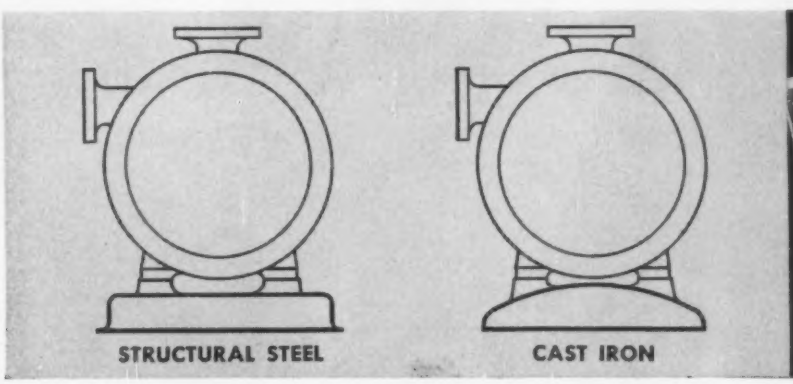
After the countdown—a roaring and soaring! The fuels that make rockets roar contain highly abrasive solids, ignite and burn rapidly with the slightest contact with air or oxygen. Handling them is a problem—pumping temperatures run as high as 550° F. For one government installation, Goulds developed a vertical process pump with an inert gas chamber that is used as a barrier between pumpage and rotating shaft seal. Gas pressure is maintained by an automatic purgerator slightly above suction inlet pressure to insure no contact between the mechanical seal and the abrasive solids. This pump has been found so broadly applicable that it is now a standard model in our line.

Now . . . a centripetal pump!

A unique use of centripetal action lets Goulds Fig. 2520 handle liquid, air, or liquid *and* air! The centrifugal force of the impeller separates the liquid from the lighter air, which accumulates at the center of the impeller and casing. The liquid, circulating at the casing periphery, is directed (by centripetal action) toward the center, pushing the air ahead of it and through the discharge. Once primed, this pump *stays* primed! It can't air bind—even with loops or leaks in your suction line. Handles foaming solutions and emulsions easily. You can use it for almost anything: as a scavenger, for transfer work, for cleaning up, for pilot plant work. Ask for Bulletin 725.6 for all the details!

Latex: Handle with Care

Before synthetic latex can become the bouncy consumer products you see here, it must be a fairly instable liquid, able to gel or coagulate easily. For that reason, a pump must handle latex gently or the impeller will clog and have to be cleaned frequently. Such a pump is the Goulds Fig. 3715—six of which are presently being used by a rubber manufacturer to transfer latex from storage tanks to tank cars and in the latex concentrator line. A semi-open impeller allows a minimum of mechanical shock or friction at optimum efficiency. Normal cleaning operations are performed easily, because the casing cover and impeller can be easily removed without disturbing pipe connections. Bulletin 725.4.



Cast-iron bedplates

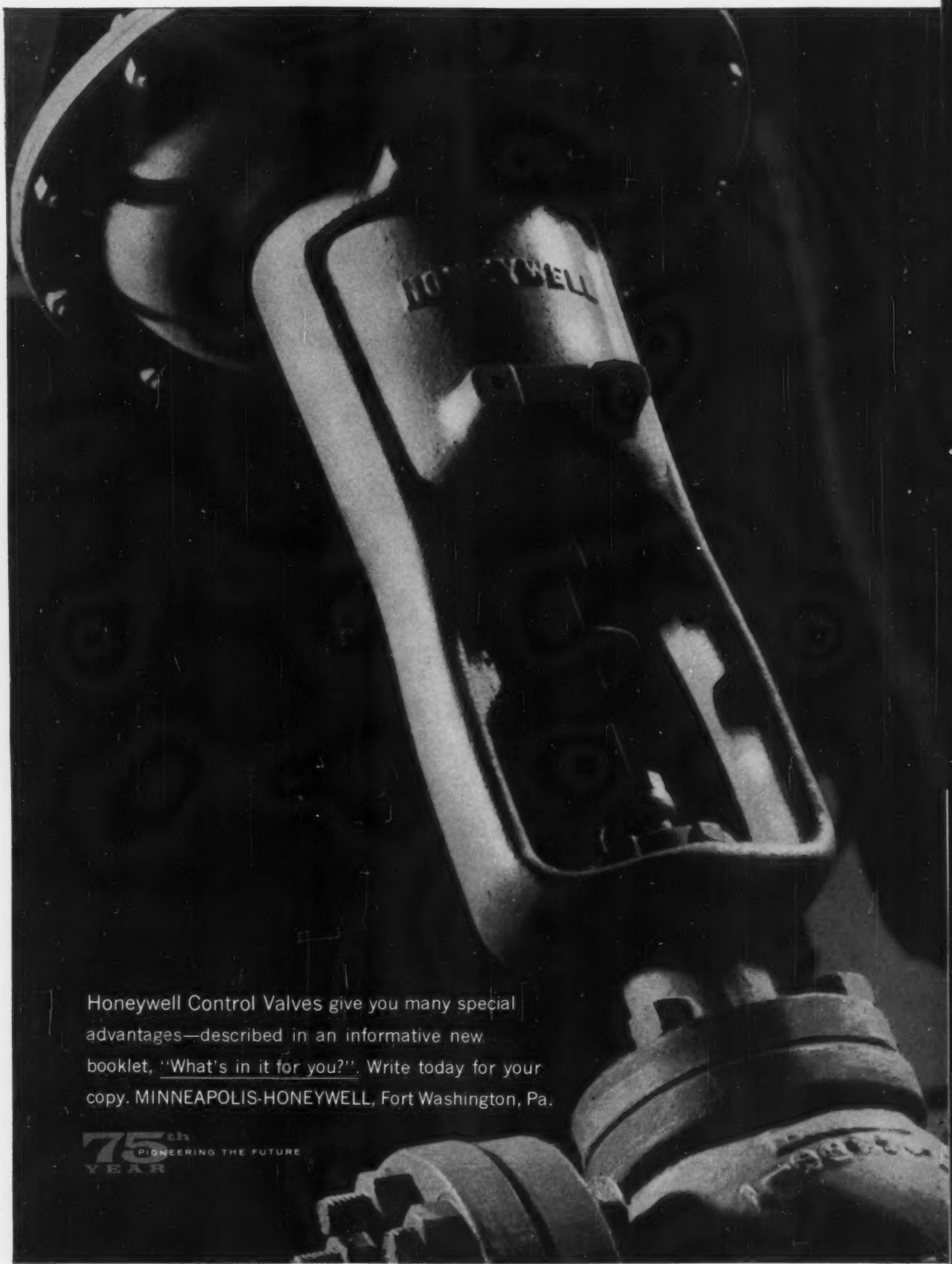
A rigid well-grouted bedplate under your pump and driver is the first requirement for trouble-free operation. Accordingly, Goulds furnishes rigid corrosion-resistant cast-iron bedplates as standard at no extra cost. The Goulds special camber top prevents accumulation of corrosive liquids. The camber design with its large accessible grout hole at the high point insures complete fill-up of bedplate cavity with grout. This economical design, jig-drilled for pump and motors, provides integral motor pad, eliminating costly separate motor base.

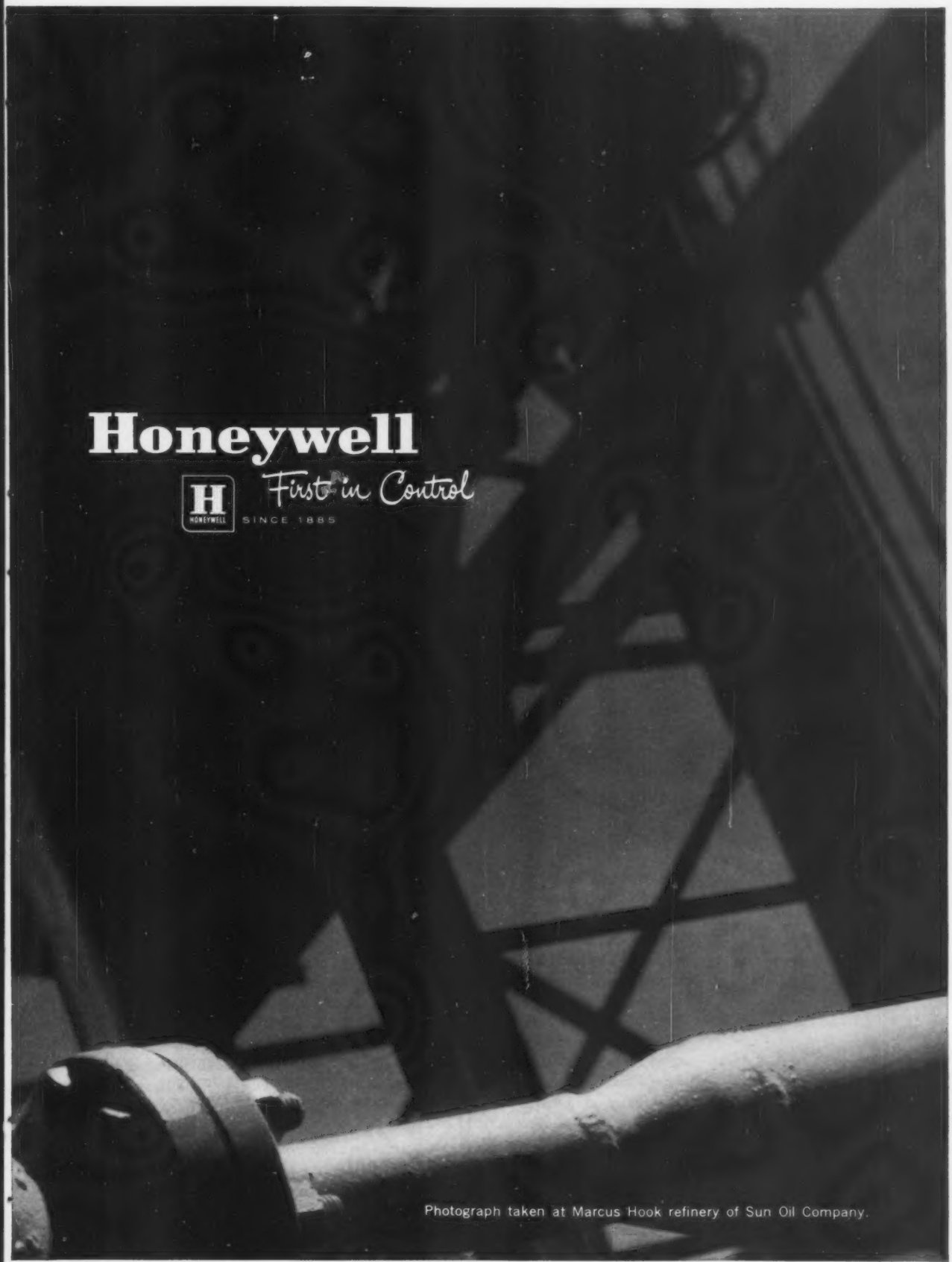
Get all the news monthly—FREE!

If you've liked reading about the new designs and applications of pumps as presented on PUMPAGE, then you'll appreciate getting a sister publication, GOULDS NEWS, mailed to you free every other month. GOULDS NEWS is a 4-page newsletter that highlights new developments in pumps and profitable ways that they are used. You can add your name to our mailing list by merely writing, on your letterhead, to Goulds Pumps, Inc., Dept. PR-20, Seneca Falls, N. Y.

GOULDS GP PUMPS

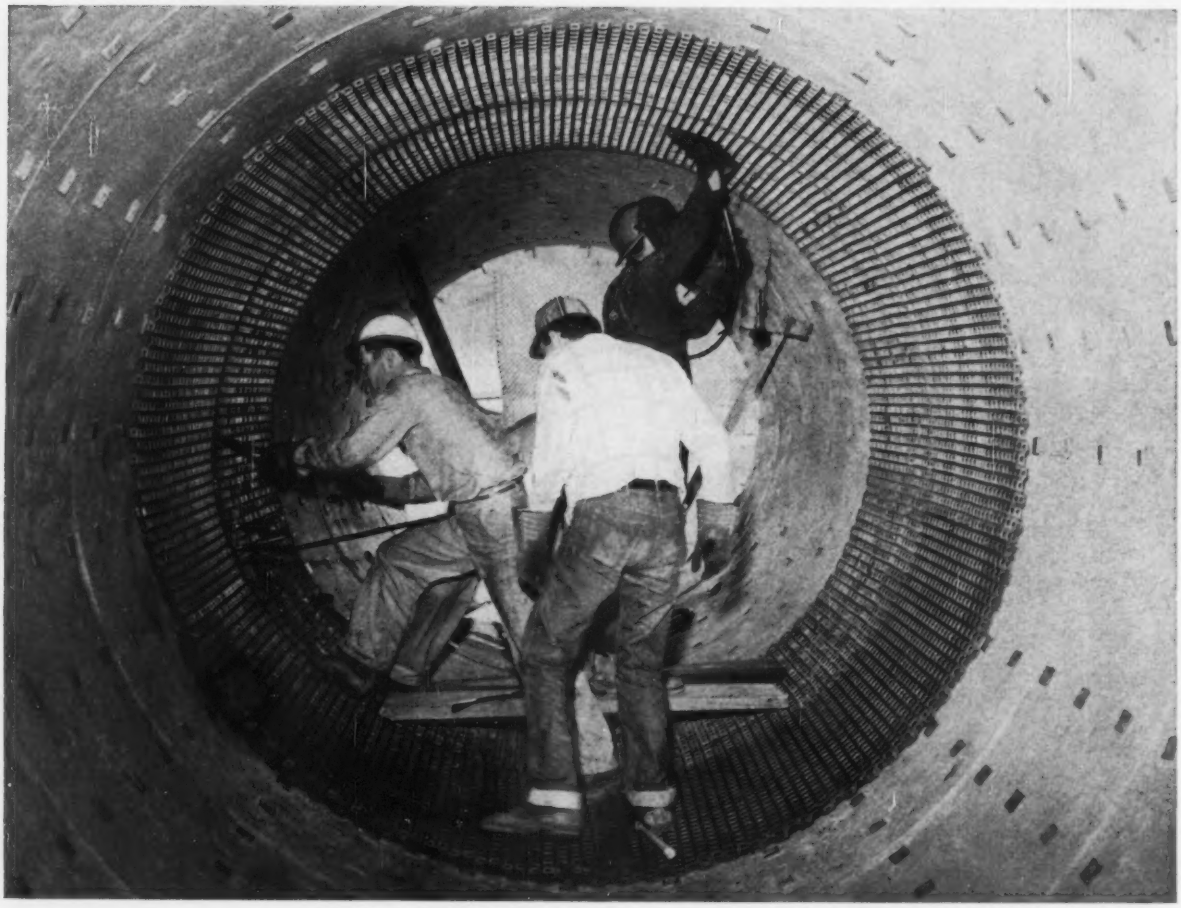
For more data on advertised products, use Readers' Service Cards, last page.


Honeywell Control Valves give you many special advantages—described in an informative new booklet, "What's in it for you?". Write today for your copy. MINNEAPOLIS-HONEYWELL, Fort Washington, Pa.
75th YEAR
PIONEERING THE FUTURE



For more data on advertised products, use Readers' Service Cards, last page.

Refractory insulating concrete protects catalyst lines against erosion



Gunite Contractor: J. A. McCollum, Inc., Marlton, N. J. Castables: Kaiser Refractories & Chemicals Div.

In this catalyst line at a large Gulf Coast refinery, steel mesh is being welded into place over a 3-inch lining of refractory insulating concrete made with LUMNITE calcium-aluminate cement. Over the mesh, a 1-inch thickness of high-strength castable will be gunited, providing a 2-component refractory concrete lining that will resist severe erosion and abrasion caused by catalyst fines. Monolithic refractory concrete linings eliminate troublesome mortar joints. They are easily placed, conforming to any contour. Castables are recommended because they are simply mixed with water and placed – concrete reaches service strength in 24 hours. Castables containing LUMNITE cement are available from leading manufacturers of refractories for a variety of applications in refinery equipment. For information, write Universal Atlas Cement, 100 Park Avenue, New York 17, N. Y.

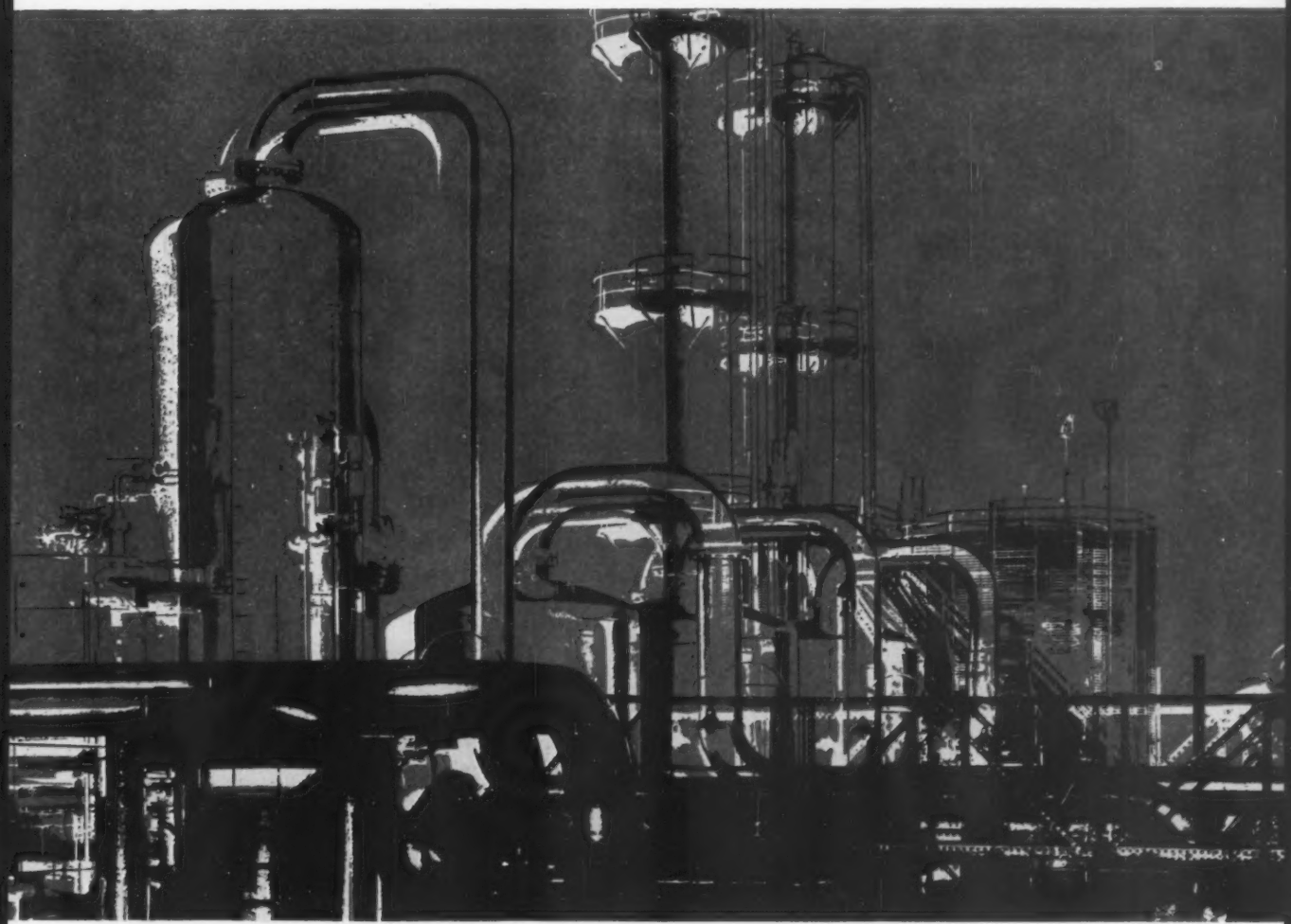
"USS," "Atlas" and "Lumnite" are registered trademarks.

Universal Atlas Cement
Division of
United States Steel

L-198

OFFICES: Albany • Birmingham • Boston • Chicago • Dayton • Kansas City • Milwaukee • Minneapolis • New York • Philadelphia • Pittsburgh • St. Louis • Waco

Dead or alive? *Each time tubular trouble jolts production to a standstill, you've got a half-dead refinery on your hands. And that means lost production time, maintenance or replacement costs, and missed delivery dates!*



National Tube has 24 different ways to help you keep a refinery alive. Our 60 years of dealing with tubular problems has made it possible to develop 24 seamless steel pipe and tube analyses—each designed for a specific set of refinery conditions such as exposure, oxidation, acids, corrosion, high pressures, and elevated temperatures. Other analyses are available in tubular form and a wide variety of high temperature problems are under study.

We also have a trained Mill Service Force available for field consultation. These men are ready to help you find the right alloy, at the right price, to meet your needs. So stop trouble before it starts. Get complete details by writing National Tube Division, United States Steel, 525 William Penn Place, Pittsburgh 30, Pa.

USS is a registered trademark

National Tube Division of United States Steel

Columbia-Geneva Steel Division, San Francisco, Pacific Coast Distributors • United States Steel Supply Division, United States Steel Export Company, New York

Here are National Tube's two dozen different tube analyses:

Carbon	5 Cr, ½ Mo	17 Cr
Carbon, ½ Mo	5 Cr, ½ Mo, 1½ Si	18-8
1 Cr, ½ Mo	7 Cr, ½ Mo	18 8 Ti
1¼ Cr, ½ Mo	8 Cr, ½ Mo	18-8 Cb
2 Cr, ½ Mo	8 Cr, 1 Mo	18-8 Mo
2¼ Cr, 1 Mo	9 Cr, 1 Mo	25-20
2½ Cr, ½ Mo, ¾ Si	12 Cr	3½ Ni
3 Cr, 1 Mo	12 Cr, Al	5 Ni

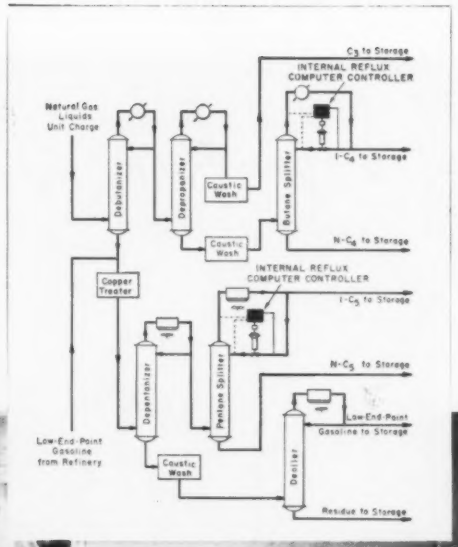
The world's largest and most experienced manufacturer of tubular products

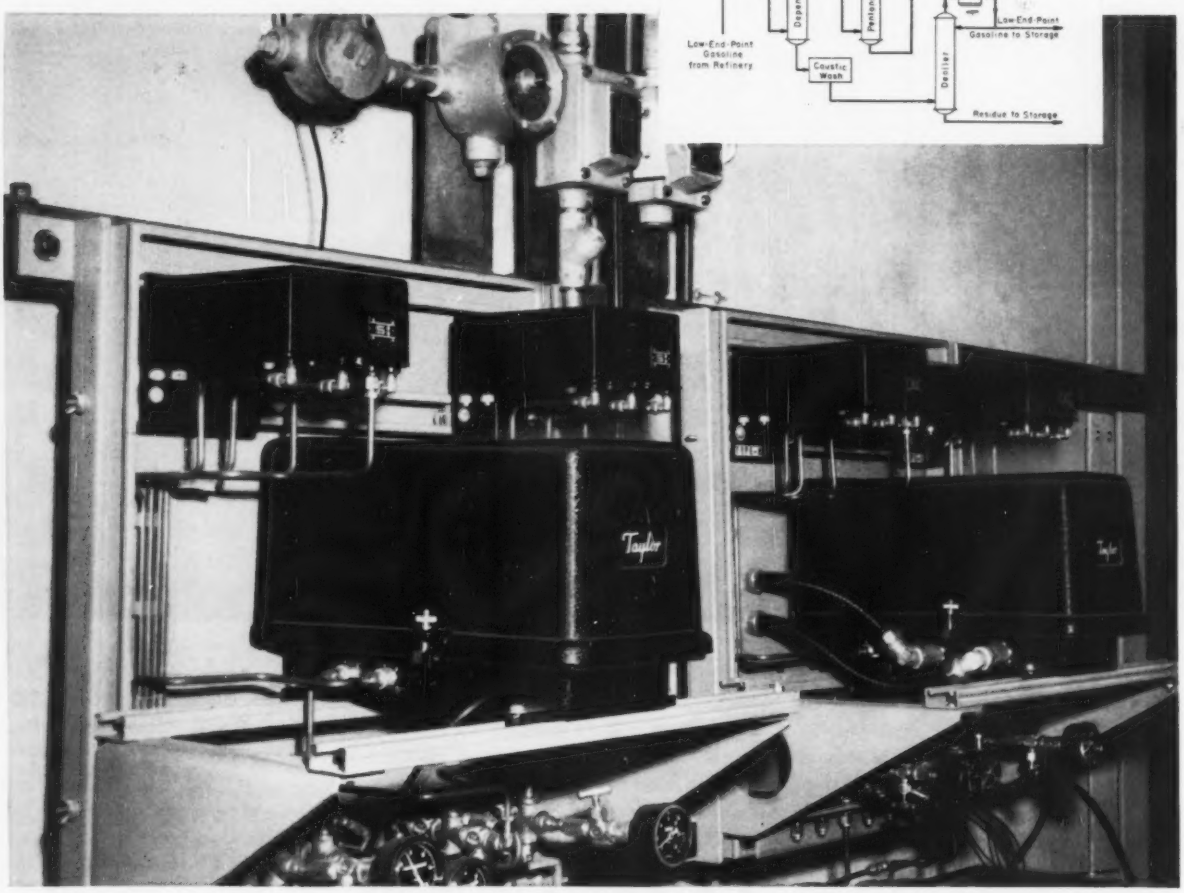
For more data on advertised products, use Readers' Service Cards, last page.

MORE PROFIT PER

Drawing at right shows the Taylor Internal Reflux Computer System, installed at Phillips' Sweeny, Texas, Refinery on LP gas fractionation columns. It can be supplied with either pneumatic or electrical output. It fits into any control system already installed—also into any large scale digital or unit analytical computer installation. Set point can be adjusted manually by the operator or automatically from column temperature, process analyzers and/or computers, etc.

Components are all standard, proven units. The Taylor Potentiometer Transmitter permits the use of thermocouples in place of special resistance elements for narrow span differential temperature measurement.





Taylor Computer-Controllers in use on the light ends fractionation system, typical of several systems in use as shown in drawing above.

Taylor Instruments

BARREL OF PRODUCT...

Phillips Petroleum Co. reports optimum fractionator efficiency with Taylor Internal Reflux Computer Control

THE Taylor Internal Reflux Computer Control System consists of the addition of a simple analog computer to a fractionating column. It maintains optimum reflux flow by instantly compensating for climatic effects encountered in outdoor installations. This means:

1. Consistent product quality—no rerunning or blending.

2. Maximum utilization of existing installation.

3. Minimum consumption of steam, air and water.

4. Elimination of flooding—run to design capacity without loss of product.

5. Increased production with no process change. Adaptable to any column design and existing piping and instrumentation.

• • •

Here are Phillips Petroleum Company's answers to questions commonly asked about this system:

Are steam savings effected when using Internal Reflux Computer Controls?

"They minimize reflux adjustments necessary for day and night ambient temperature changes, thereby effecting steam savings. At the same time they contribute to the maintenance of overhead product specifications. A lower reflux ratio obviously saves steam".

Are increased product yields realized by use of computer-controls?

"While it is difficult to pin-point exact increases, we can say they permit continued tower operation at maximum load levels. Without reflux computer-controllers, column operation must be at a less efficient level to reduce hazard of flooding".

Does use of computer-controllers permit use of lower reflux-to-product ratio?

"Yes—particularly when operating to maintain product specifications, such as a minimum of 95% isopentane overhead product. Without computer-controllers it would be necessary to operate at 97% isopentane to insure a minimum 95% product".

Do computer-controllers help meet product specifications?

"Yes—they compensate and 'short-stop' transient column conditions resulting from minor temperature, pressure and feed composition changes. It is no longer necessary to have product samples analyzed in the laboratory to serve as a guide for the operator to make changes in external reflux flow rate".

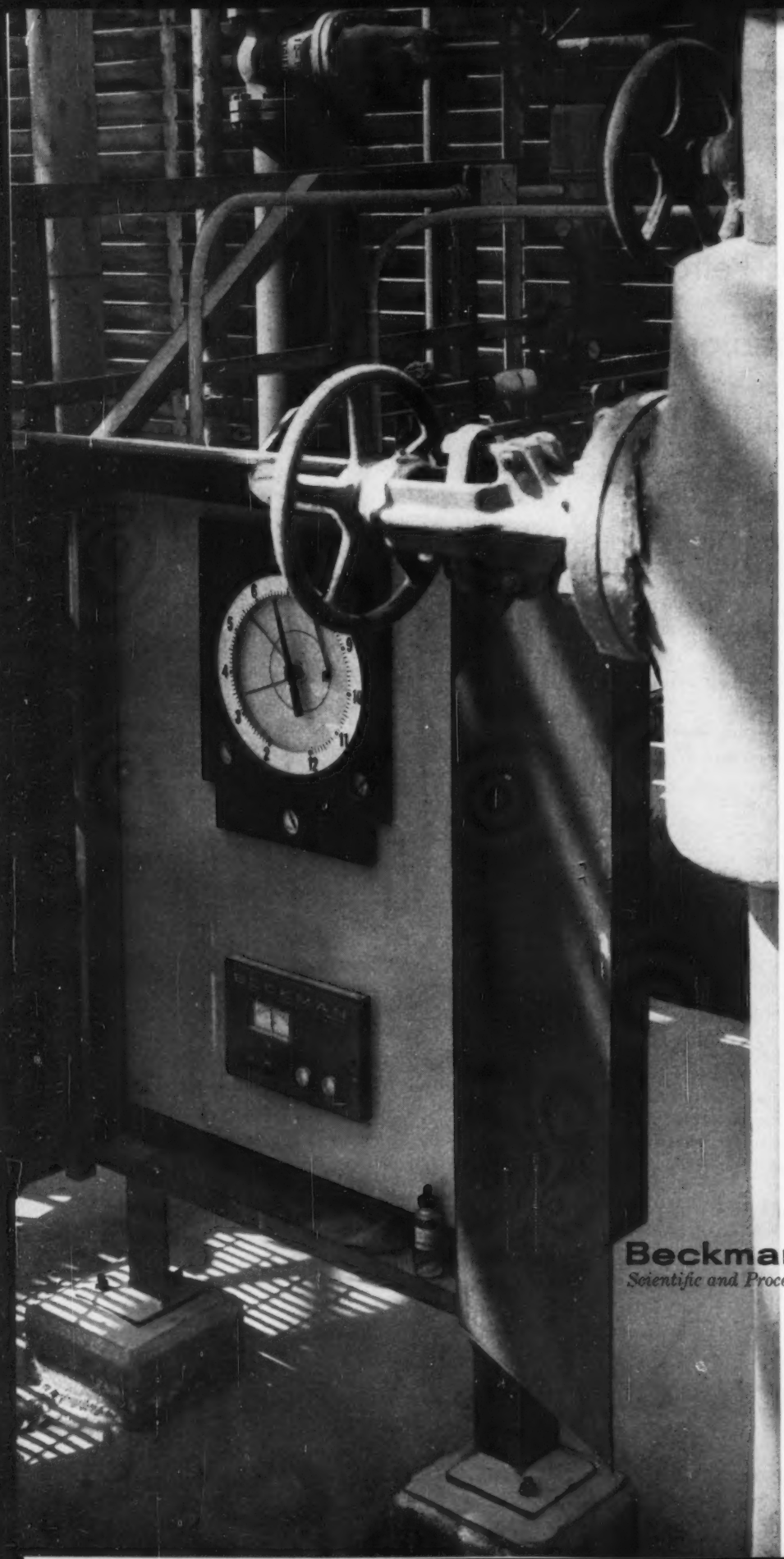
Are plant operators pleased with the performance of computer-controllers?

"They are well pleased with the installations. They appreciate the smoother column operation and ease of meeting product specifications."

• • •

Ask your Taylor Field Engineer for full information about this system, developed and licensed by Phillips Petroleum Company, or write Taylor Instrument Companies, Rochester, N. Y., or Toronto, Ontario.

MEAN ACCURACY FIRST



4 minutes' attention for 24-hour operation

Just 4 minutes a day and a Beckman Model W Industrial pH meter are all it takes for a technician to prevent equipment corrosion by continuous pH control of cooling tower water at Collier Carbon and Chemical Corporation, Brea, California.

For over two years, this small Beckman pH amplifier has continuously maintained cooling water at a pH of 6, correcting all variations automatically in about 15 seconds. And, except for the few minutes attention required every morning for routine meter standardization, it has provided maintenance-free operation.

Beckman pH equipment can also give *you* dependability with minimum attention. The reason: printed circuitry, plug-in assemblies, and ruggedized industrial electrodes.

Beckman makes and sells more industrial pH equipment than any other manufacturer in the world. Equipment and services are provided by leading recorder companies. For a list of these companies and instrument specifications, write for Data File 25-2-06.

Beckman
Scientific and Process Instruments Division
Beckman Instruments, Inc.
2500 Fullerton Road, Fullerton, California

It's a Fact: More than 500,000,000 hours have been logged by Beckman industrial pH meters...measuring and controlling pH in industrial processes.

SOME FACTS AND FALLACIES ABOUT PACKED TOWERS

☑ **Packed towers are practical in diameters over 3 ft.**

TRUE. Modern tower packings, such as "Intalox"® saddles and metal Pall Rings have made an old "rule-of-thumb" obsolete. Formerly, engineers were hesitant to use packed towers over three feet in diameter, especially where distillation was involved. However, the high efficiencies and low pressure drops of these new packings have made large diameter towers a practical and economical mass transfer tool. We can cite distillation, absorption and even liquid-liquid extraction towers in successful operation whose diameters run 8 ft. or more.

☒ **Packed towers give higher pressure drops than tray columns.**

FALSE. Because of their low pressure drops, "Intalox" saddles and metal Pall Rings have found wide application in vacuum distillation. In these rather critical rectifications, metal Pall Rings, especially, have such low resistance that pot temperatures —and product pyrolysis—are maintained at a minimum. Moreover, these low pressure drop properties lead to smaller tower diameters with greater liquid irrigation densities and lower H.E.T.P.

☑ **Packed towers have lower first cost than tray towers.**

TRUE. Again, this is true because of the development in recent years of unique packing shapes. Their high capacity and greater mass transfer efficiencies permit the design of shorter and narrower columns, requiring smaller fluid moving equipment. Where corrosion is a factor, the low cost of chemically inert ceramic packings means impressive savings over the cost of special corrosion-resistant alloys.

☑ **Packed beds make efficient entrainment separators.**

TRUE. Mist elimination sections consisting of packed beds are used in commercial scrubbing equipment, even where the scrubbing sections themselves consist of trays. Moreover, the chemical engineering literature quotes many actual installations in sulphuric acid and other plants where satisfactory performance is being obtained from packed beds. Where fouling is a problem, the choice of the proper packing with a large interstitial free space, combined with adequate hydraulic radius, will prevent deposition of solids and thus maintain low pressure drop.

☒ **Performance of packed towers can't be predicted accurately.**

FALSE. Today packed tower performance can be predicted about as accurately as that of plate columns. That was not true, however, ten years ago. Accurate design data are multiplying rapidly as the use of packed columns continues to grow at a rapid pace. Extensive research being made in packed towers up to 30″ in diameter is providing data that can be used to predict the performance of towers up to 25′ or more with reasonable accuracy.

YES, *the introduction a few years ago of "Intalox" saddles, and, more recently, the metal Pall Ring, used with properly designed packed tower internals, has brought about a re-evaluation of methods used to effect mass transfer . . . have made yesterday's facts, today's fallacies. In new tower design, or to obtain greater capacity or better efficiency from present towers, it will pay you to investigate modern packed tower performance.*

Are you on our mailing list to receive new technical data on packed tower performance as it is released from our experimental laboratories? If not, drop us a note on your letterhead. No cost or obligation. Write Dept. PR-260, The U. S. Stoneware Co., Akron 9, Ohio.

9G

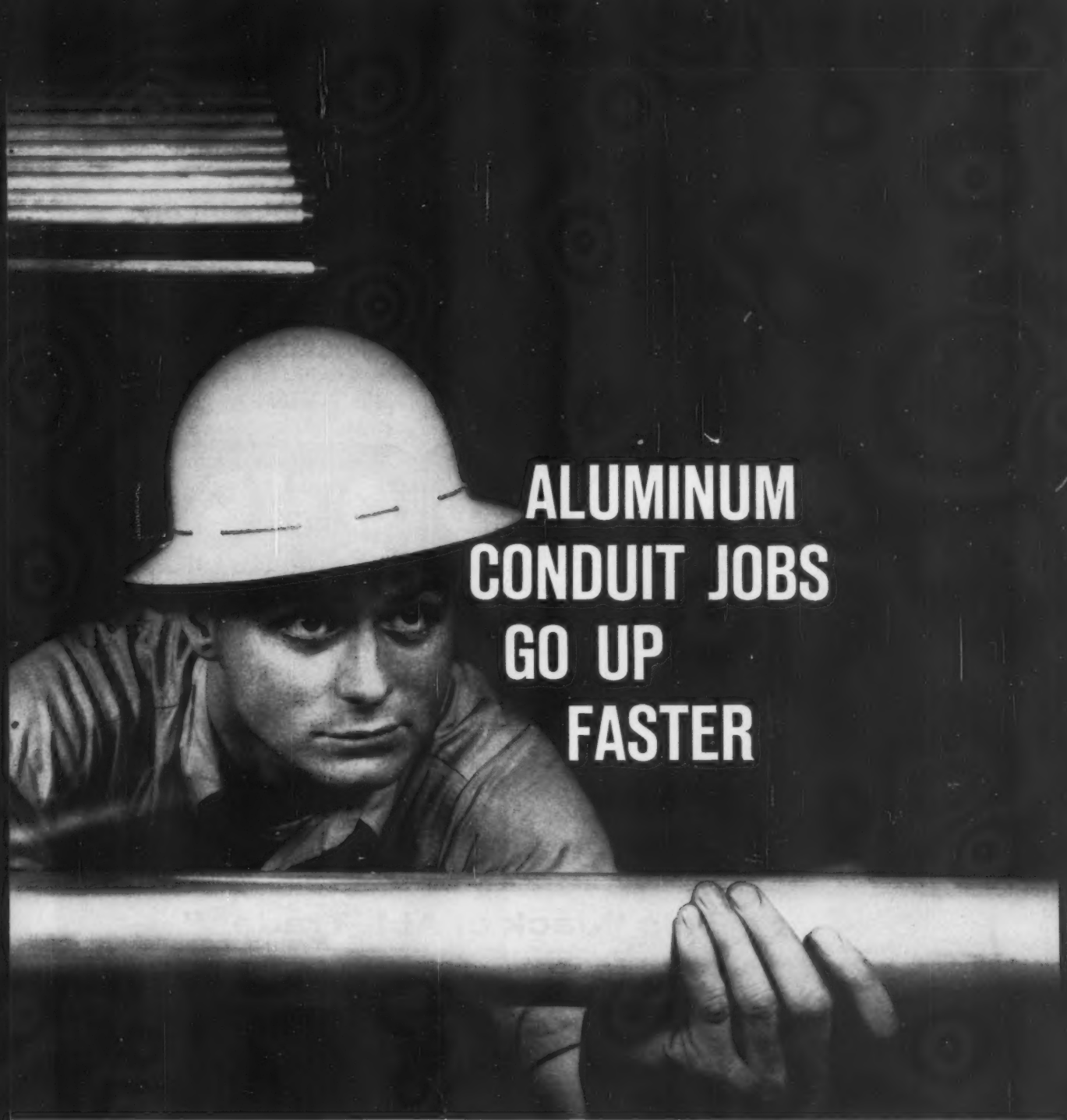
U. S. STONEWARE

AKRON 9, OHIO

For more data on advertised products, use Readers' Service Cards, last page.

HERE'S WHY:

Light weight—weighs only ⅓ as much as steel . . . **easier to handle** regardless of the job . . . **easy to cut, bend and thread,** and without special tools . . . **competitive in price** for initial savings as well as future savings . . . **corrosion resistance** means no maintenance under normal service conditions . . . **non-sparking** for safer installations . . . no special nonsparking tools required . . . **nonmagnetic** properties mean less voltage drop . . . **good appearance** that lasts and lasts . . . **color coded** for fast, accurate size identification. **Approved by Underwriters' Laboratories, Inc.** . . . and it's **available from local distributor stocks** for fast, dependable delivery.



Aluminum conduit not only makes jobs go up easier, faster and therefore more profitably, but also helps give you a higher quality, longer lasting installation. Why not use aluminum conduit on your next job? Start enjoying all the many advantages which only timesaving, costsaving aluminum conduit can provide. Your local Alcoa or Rome distributor can give you all the facts and figures for any particular installation. Or, write to Rome Cable Division of Alcoa, 2144-M Alcoa Bldg., Pittsburgh 19, Pa.

ROME CABLE DIVISION OF **ALCOA**

ALCOA
ROME CABLE
DIVISION

Your Guide to the Best in Aluminum Value

For exciting drama watch "Alcoa Presents" every Tuesday, ABC-TV, and the Emmy Award winning "Alcoa Theatre" alternate Mondays, NBC-TV

So many ways the *FISHER/MAN*
can give you a helping hand with the

WIZARD II
PRESSURE CONTROLLERS

- Two Position Controller
- Proportional Controller
- Proportional Controller —Remote Set
- Differential Proportional Controller
- Pressure Transmitter
- Differential Proportional Controller— Remote Set
- Proportional Reset Controller
- Differential Proportional Reset

This "Jack of ALL Trades" is surprisingly low in cost

The partial list of applications at left tells you why the Wizard II is so aptly named. Probably no other controller in the Fisher line is as versatile. Available in brass, steel or stainless steel Bourdon tubes for ranges from 25 to 10,000 psi. Brass or stainless steel bellows available for low pressure service from 30" Hg Vacuum to 30 psi.

Fisher has carefully designed each component of the new Wizard to satisfy the most rigid process control requirements. A completely descriptive and illustrated booklet on the Wizard II is yours for the asking. Write for Bulletin D 4150 A.

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD . . . CHANCES ARE IT'S CONTROLLED BY . . .

FISHER GOVERNOR COMPANY

Marshalltown, Iowa / Woodstock, Ontario / London, England

CONTINENTAL EQUIPMENT CO. DIVISION, Coraopolis, Pennsylvania

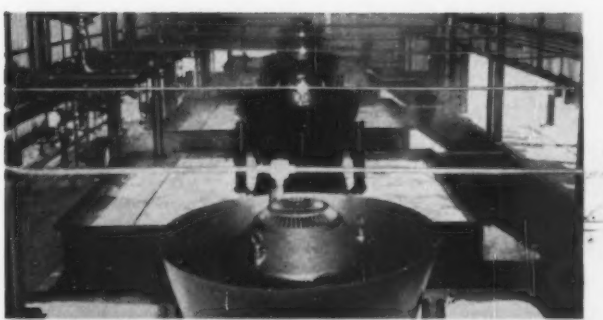
FISHER® Controls

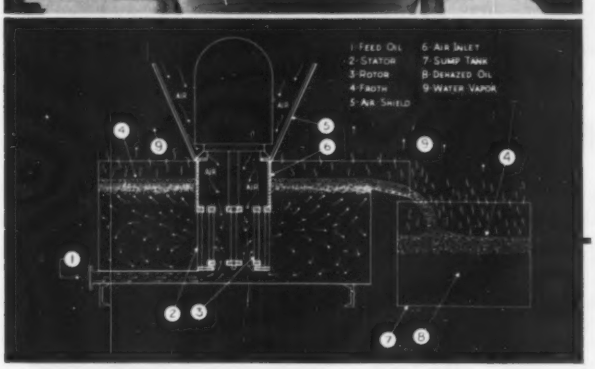
SINCE 1880

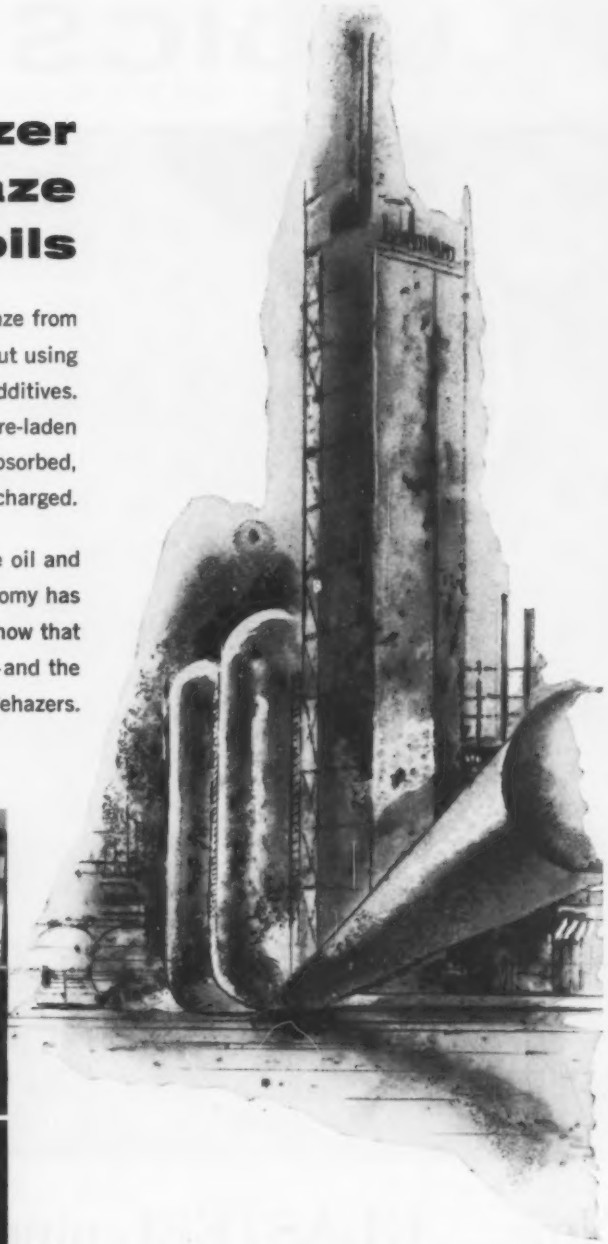
Hendrick dehazer lifts the haze from refinery oils

The Hendrick Hydro-Dehazer removes haze from refinery oils quickly and economically, without using compressed air, high heat, chemicals or other additives. The Hydro-Dehazer's huge rotor mixes moisture-laden oil with free air until the moisture is absorbed, rises to the top, and is discharged.

Produces bright, haze-free furnace oil and diesel fuel at 400 B.P.H. Economy has been proven in installations which show that Hendrick has the most efficient method—and the lowest operating cost—of all dehazers.







Hendrick will be glad to arrange a free demonstration. For details, mail this coupon today.

HENDRICK MANUFACTURING COMPANY
36 Dundaff Street, Carbondale, Pennsylvania

Gentlemen: I am interested in learning more about the new Hendrick Hydro-Dehazer.

☐ Please arrange demonstration of the Dehazer Pilot Model.

☐ Please send technical data.

NAME_____ TITLE_____

COMPANY_____

STREET ADDRESS_____

CITY_____ STATE_____

Hendrick
Manufacturing Company
Carbondale, Pennsylvania

PERFORATED METAL · PERFORATED METAL SCREENS · WEDGE-SLOT AND HENDRICK WEDGE WIRE SCREENS · ARCHITECTURAL GRILLES MITCO OPEN STEEL FLOORING · SHUR-SITE TREADS · ARMORGRIDS HENDRICK HYDRO DEHAZER · DISTILLATION COLUMN INTERNALS FLUIDIZED BED PERFORATED PLATES AND GRIDS

For more data on advertised products, use Readers' Service Cards, last page.

FLUIDICS* AT WORK

Now... GLASTEEL pipe that you can field-cut

That's new Pfaudler F-C Glasteel pipe* you see being cut with a standard, dry abrasive cutoff wheel.

The F-C stands for "field cut." The pipe itself is steel on the outside for strength, borosilicate glass on the inside for corrosion resistance. Once you've cut the length you want, you thread and then fire-polish with a small, portable furnace. (Furnace available from Pfaudler at a modest cost that you will completely recover through savings in a few installations.) You finish the pipe end with a belt sander to make sure that the gasket seat is flat and the flange connection seal-tight.

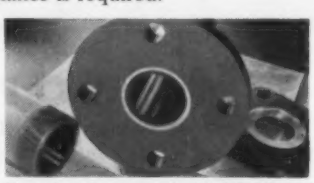
Glass lining for this new pipe is ⅛ inch thick, so you can expect substantially longer service life even with corrosive and/or abrasive fluids. Rated at 150 psi and available in 1½, 2 and 3 inch diameters, F-C pipe can be used with all acids (except HF) to 350° F. and with all mild alkalies at moderate temperatures.

Moreover, since glass is inert, you will also find this pipe useful for those products which must be kept free from contamination. And note, too, that because glass is smooth, there's little chance for build-up with sticky materials.

Aside from the fire-polishing furnace, you will find the tools needed for handling F-C Glasteel pipe in most plant maintenance shops. There is no need to engineer a piping layout to the last ⅛ inch. Installation and modification are easy, and very little maintenance is required.

As of now, you can get limited quantities from stock in lengths through 10 feet. For Bulletin No. 989, please write to our Pfaudler Division, Dept. PR-20, Rochester 3, N. Y.—See a live demonstration at the Corrosion Show in Dallas.

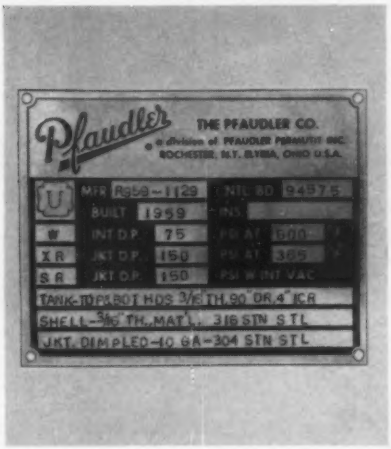
*Patent applied for



Thread-on flange used with F-C Glasteel pipe is ASA 150# Series. Gasket features corrosion-resistant Teflon envelope at product contact area.

Code approval is one measure of quality in stainless reactors

This code plate on a Pfaudler stainless steel reactor tells you that every detail of construction—materials, design, workmanship—is of the highest quality.



But how can you measure quality on a non-code vessel?

At Pfaudler, both are essentially the same. Whether you require code approval or not, specify X-ray inspection, need type 304 or 316 stainless, your reactor is made in the same plants, by the same workers, following the same designs and under the same quality standards.

There is more than quality in the Pfaudler hallmark. It also includes:

5 to 2,000 gallon capacities. Complete range of sizes for convenient scale-up of your process, lab to pilot plant to production.

Standard design. Makes process line change-over easy; reduces cost of units; lets us stock reactors, provide 2-week delivery on certain sizes.

"Dimpled" jackets. Pfaudler's unique stainless dimpled construction enables you to operate economically at temperatures as high as 600°F. and jacket pressures to 150 psi. Code approved. 175 psi is available on custom designs. Dimpled jackets also give you higher heat transfer rates than conventional designs.

Dollar savings. We help you pick lowest cost construction—usually conventional jacket design up to 750 gallon size and/or 100 psi, then "dimpled" construction for higher capacities or pressures.

Free bulletin. You can study the details and specifications of Pfaudler stainless steel reactors in our Bulletin 944. Write for a copy.

New from Permutit!*... Complete Line— All Purpose Model BD Economy Softeners

Permutit Model BD Softeners answer industry's demand for more and more soft water at lower cost. Taking advantage of new design advancements and standardized mass produced components, Model BD Softeners now make Permutit quality available in a complete line, ready for prompt delivery from stock at economy prices.

New Permutit Model B Water Softener provides high quality and capacity at a low price.

BD Softeners contain only high capacity Permutit Q Resin. Absence of subfill eliminates possibility of upsetting bed, makes installation simpler, less expensive. Exclusive double-dish underdrain is shipped completely assembled, further simplifies installation. Standard valve is the famous Permutit Multiport® type.

Permutit Model BD Softeners are available in the following sizes and capacities:

Shell Diam.	Straight Ht.	Flow Rate Average	Softening Capacity
30"	6'	40 gpm	510 Kgr
36"	6'	56 gpm	750 Kgr
42"	6'	77 gpm	1020 Kgr
48"	6'	100 gpm	1380 Kgr

Write for specifications and complete information.

FLUIDICS AROUND THE WORLD

Pfaudler Permutit is a world-wide company with manufacturing plants in: Germany, Great Britain, Canada, Mexico and Japan, as well as four plants in the U. S. A.

*FLUIDICS is the Pfaudler Permutit program that integrates knowledge, equipment and experience in solving problems involving fluids.

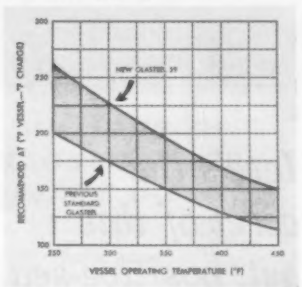
Increased thermal shock protection with Glasteel 59

Chilling ice water hits a 450°F. test plate of Glasteel 59—there is no thermal shock damage.

This laboratory test shows the thermal shock resistance of Glasteel 59 to be 30% greater than our best previous glassed steel.

Process equipment constructed of Glasteel 59 carries a comfortable safety factor of *three*, based on our laboratory results.

When the contents of a Glasteel vessel are *colder* than the vessel wall or jacket medium, the safe temperature differential varies with the vessel temperature as shown in the following graph—



However, when the Glasteel vessel contents are *hotter* than the vessel wall or the jacket medium, a constant 260°F. Δ T may be figured throughout the entire operating range of the equipment.

Thermal shock protection is just that—protection. It is there for you when you need it. And Glasteel 59 offers you exceptionally more protection—a full 30%.

Corrosion resistance. You can work with any acid (except HF) to 350°F. and even to 450°F., depending on concentration. For resistance to alkalies, Glasteel 59 outperforms hard glass labware by a factor of two.

Abrasion resistance. Glasteel 59 provides abrasion resistance that's 20% greater than our previous glassed steel.

Surface. Glasteel 59 is very smooth. There is little chance for build-up, so it's easy to clean.

Offer. Our Buyer's Guide gives a general review of available Glasteel 59 process equipment.

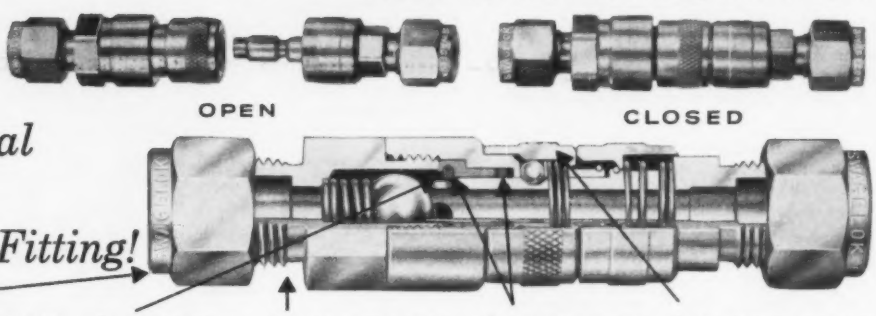
PFAUDLER PERMUTIT INC.
Specialists in FLUIDICS . . . the science of fluid processes

For more data on advertised products, use Readers' Service Cards, last page.

What's the secret of this fast, positive-seal fitting?

Swagelok Quick-Connect Fitting Installation in Boeing Airplane Company, Seattle, Wash., Test Facilities for Boeing 707 Jet Stratoliner.

Here's the secret of this fast, positive-seal Swagelok Quick-Connect Fitting!



1. Swagelok Quick-Connects with single end or double end shut off for tube to pipe, tube to tube, bulkhead tube to tube applications are available in brass and stainless steel in sizes for ¼" and ⅜" O. D. tubing.

2. Flow resumed instantly and vacuum tight seal assured when connection is made.

3. Light, compact, streamlined design. Occupies little space. For use with portable equipment, and bulkhead or panel applications.

4. Instant-acting seals completely prevent loss of pressure when fitting is disconnected.

5. No twisting, turning or wrench action necessary. Easy straight-line finger tip pull or push action for instant connecting or disconnecting.

In the Boeing Airplane Company photo shown above, the tubes are instrumentation pressure lines running from the large jet engines on test stands to the patch board, where the lines are coupled into measuring devices.

The Boeing Airplane Company adopted this positive Swagelok Quick-Connect Fitting to simplify test installations, and substantially cut down test set-up time. Both ends of the many pressure lines are Swagelok-equipped. Previously, engineers used a screw-type fitting which required a wrench and valuable time-consuming operations to tighten and remove.

Swagelok engineers are equipped with experience, ability, and a wide range of tube fittings designed to meet your individual problems. Quick delivery of Swagelok tube fittings from local distributor stocks.

Swagelok® TUBE FITTINGS

CRAWFORD FITTING COMPANY
884 East 140th Street, Cleveland 10, Ohio
Crawford Fittings (Canada) Ltd., Niagara Falls, Ontario, Canada

HANDLES "MOON" TEMPERATURE EXTREMES!

New low temperature insulation handles jobs in − 300° F. to + 220° F. range

Of course, this new Unarco U200 insulation is not in use on the moon . . . but it could be, because it handles temperature extremes even greater than would be required on this bleak island in space.* What's more U200 does it without thermal shock effects anywhere along the line.

A new, extremely lightweight, closed cell synthetic, U200 has excellent heat and chemical resistance. Its K factor is only 0.14 at 70° F. mean temperature . . . lowest on the market. Density is only 2.3 lb. per cubic foot. Yet this remarkable, new material has high compressive and flexural strength. It's non-toxic and easy to handle, too.

Try it just once and you'll see how quickly and easily it can be cut and applied with a very minimum of standard hand tools. It can actually reduce application costs by as much as 50%.

Available in accurate, half-round sections; in nominal thicknesses and in standard pipe sizes. Individual sections 36 inches long. Also available in 12" x 36" block form—1" to 5" thickness in ½" increments.

(*) *−243° F. to +214° F. Estimated moon temperatures as listed in a leading American encyclopedia.*

Get complete engineering specifications and other details before another day goes by.

Write today on your company letterhead for Unarco Bulletin No. U200-1.

MILLIONS OF CLOSED CELLS MAKE U-200

- **Waterproof**
- **Vapor Resistant**
- **Efficient**
- **Lightweight**
- **Easy to Handle**

*Closed cell content of 85% plus.

U-200

The insulation with "Handleability"

POLYURETHANE FOAM

UNARCO®

UNARCO PRODUCTS

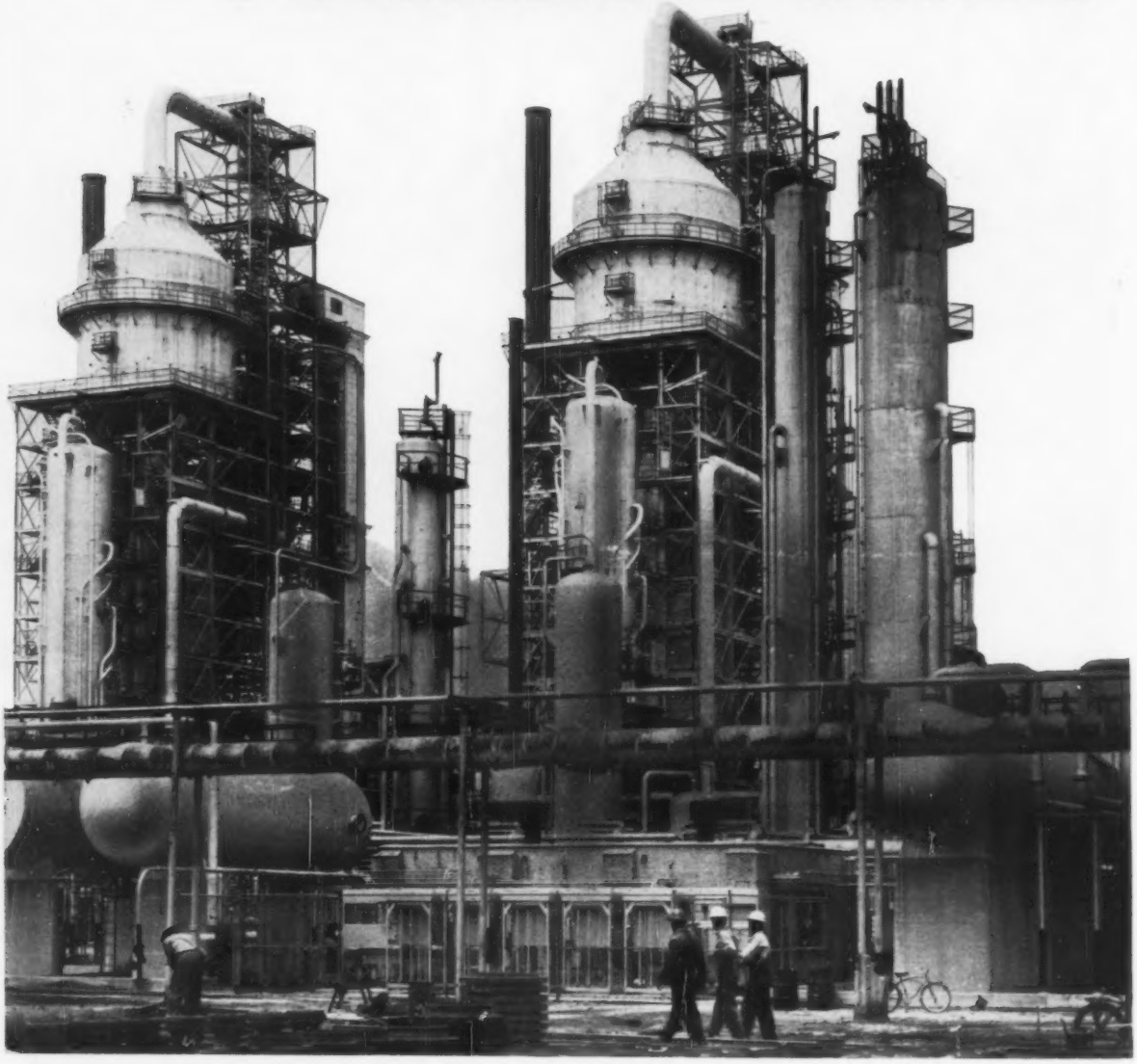
• UNIBESTOS, Amosite Asbestos Pipe Covering and Block • Calcium Silicate Pipe Covering and Block • 85% Magnesia Pipe Covering and Block • Mineral Fiber Block • Wrap-On Insulation • Lace-On Insulation • Turbine Blankets • Insulating and Finishing Cements • Asbestos Textiles • Packing and Gasketing.

UNION ASBESTOS & RUBBER COMPANY

Fibrous Products Division • **Dept. 260, Bloomington, Illinois.**

For more data on advertised products, use Readers' Service Cards, last page.

Make shorter work of TURNAROUNDS



Every OAKITE ECP utilizes chemical cleaning for towers

Where carbon and iron oxides and sulphides must be removed: circulate Oakite 85. Combining acid and solvent cleaning properties Oakite 85 penetrates heavy scales and corrosion-type soils, tears them from equipment walls, then rinses freely and completely. It's safer than raw acids, because it's inhibited against attack on ferrous metals . . . easy on synthetic rubber. One user says:

When this 40-ft., 12-tray tower was off-stream previously, "hand" cleaning required 5 days and $3,000. Using Oakite 85 by circulation method, we did a complete job of removing fouling soils in just 32 hours . . . for only $750.

For heavy oil, grease-laden soils and light rusts: circulate Oakite 77. Heavy-duty alkaline cleaning properties make Oakite 77 superior for penetrating, dissolving and dispersing heavy-oil and carbonaceous soils. It picks up light rust, too . . . leaves towers and tubes in top operating condition.

In cases where extra boosting power is called for to remove abnormally stubborn soils—add Oakite Acalaid to your cleaning solution. This brand new additive permits deeper penetration of soils . . . intensifies the purging action of your acid or alkaline cleaning agent . . . gives you a speedy, economical answer to your toughest tower-cleaning problem.

For more data on advertised products, use Readers' Service Cards, last page.

with an Oakite ECP

engineered cleaning program

A 90-foot tower cleaned in 15 hours . . . crude tower and heat exchanger purged to 99% cleanliness in 21 hours . . . partly plugged bundles saved from the scrap pile in just a few hours . . . 3½ *days* cut from previous record for cleaning an absorber . . . 5 days slashed from catalytic reformer turnaround time. These are *some* of the results of Oakite technical service.

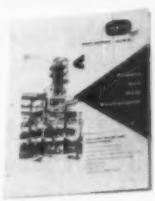
In each case, the procedure was initiated through the tower and tube bundle recommendations of an Oakite ECP. Did they save time, save cost, save trouble? You bet!

WHAT IS OAKITE ECP?

It's an Engineered Cleaning Program that stresses chemical cleaning. It's engineered specifically for your refinery, for your cleaning problems, and for each cleaning operation—tower by tower, valve by valve.

The Oakite engineer lends personal and experienced supervision to each phase of the program. He supplies detailed instruction based on practical knowledge of refinery cleaning needs. Each Oakite ECP is backed by a *laboratory* concentrating on chemical cleaning research, by materials known to make short work of refinery soils, by proved *methods.*

Ask the Oakite Engineer to recommend the best procedure for your next turnaround and follow up with an ECP for your refinery. Or, send for Bulletin F-10102 on tower and heat exchanger cleaning. Write Oakite Products, Inc., 50B Rector Street, New York 6, N. Y.



OAKITE

over 50 Est. 1909 SCIENCE

years' leadership in industrial cleaning

Oakite ECP

your economy key

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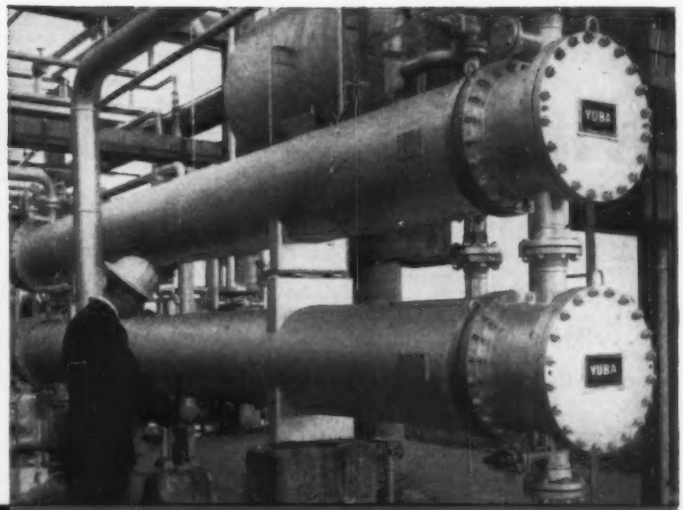
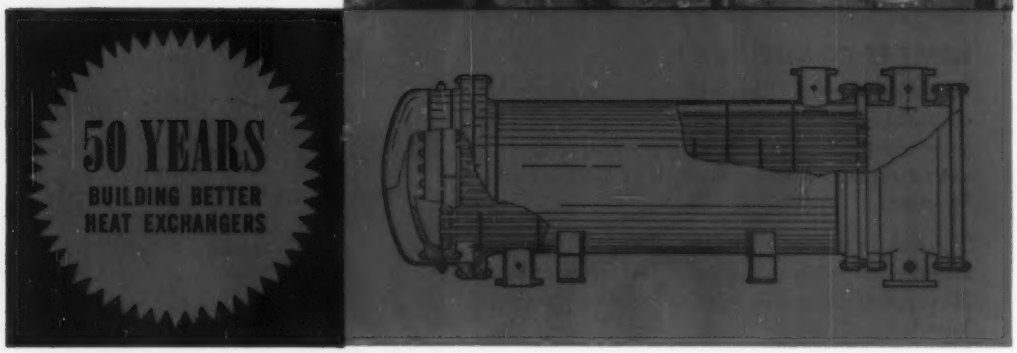
YUBA HAS THE EXPERIENCE FACTOR THAT MEANS BETTER HEAT EXCHANGERS





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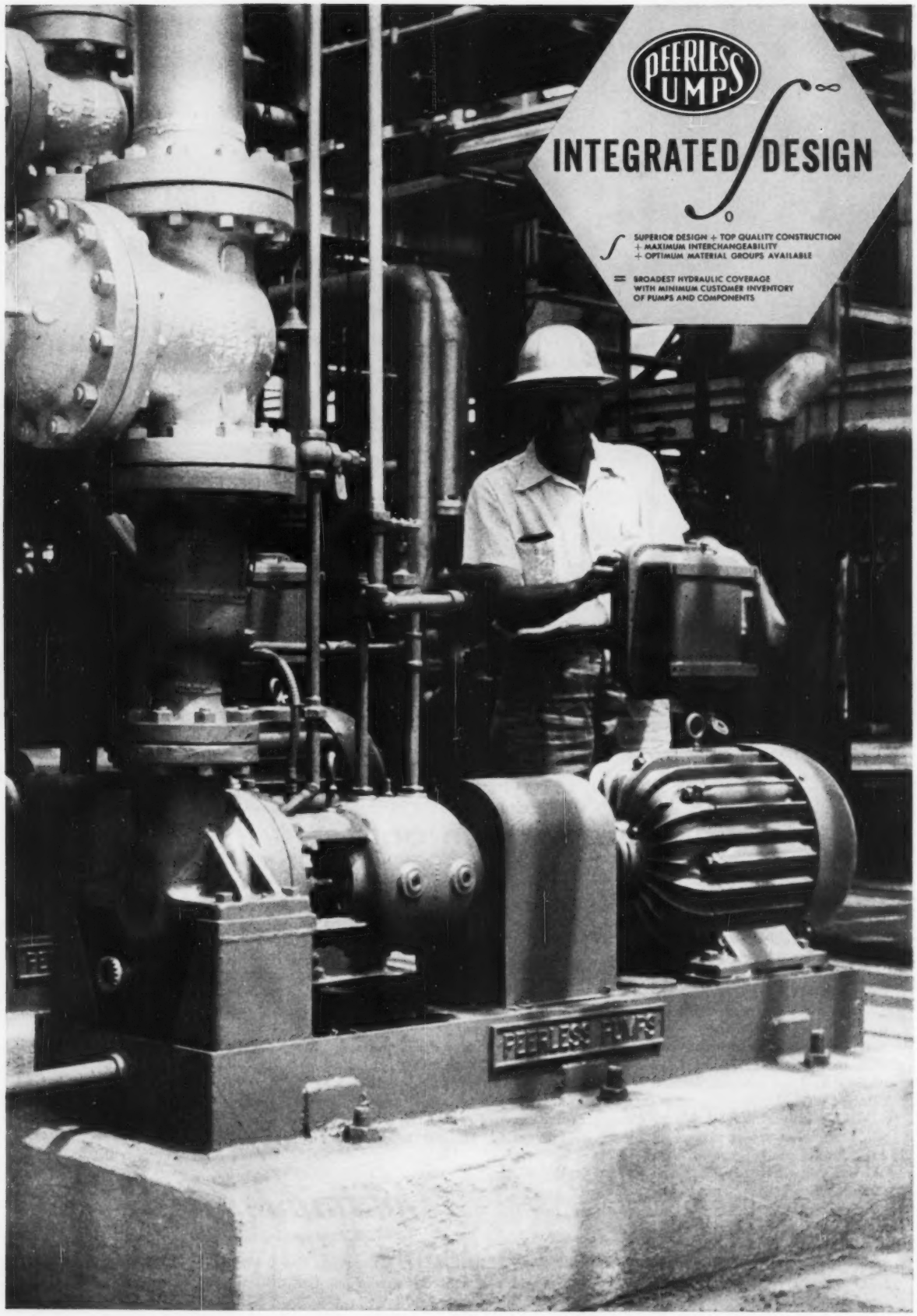
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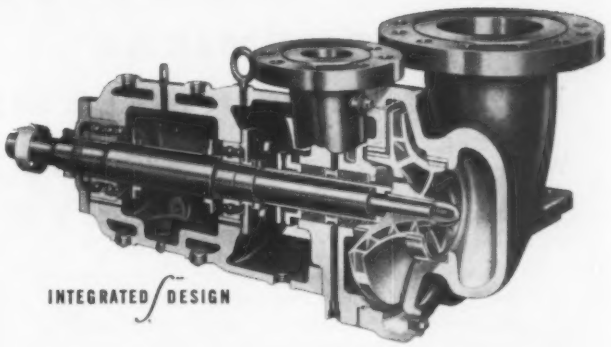

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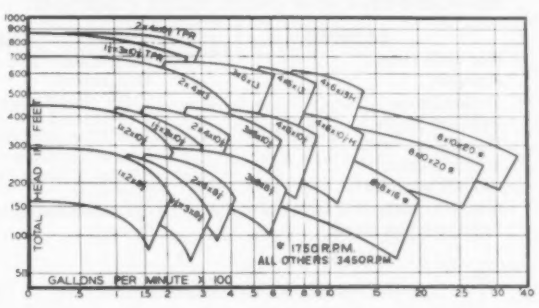

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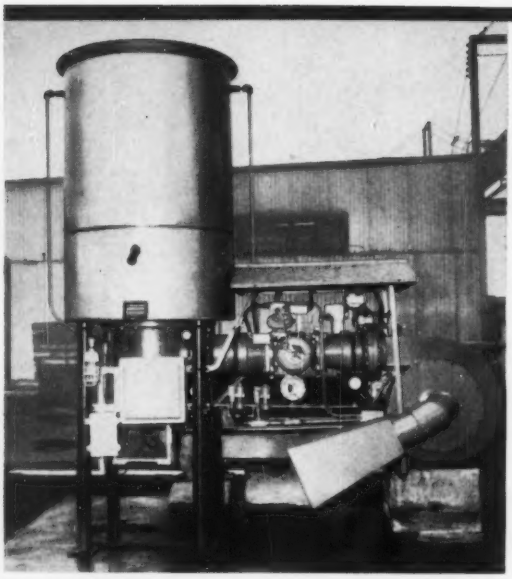

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CO and Not CO_2

To the Editor:

In May 1959's issue of PETROLEUM REFINER, you kindly published my nomograph "Find Weight of Hydrogen in Fuel Gas" in the Section "How to Do It."

Unfortunately both vertical scales were changed to "% CO_2" when you copied the graph. They should read "% CO."

Klaus Lothholz W.
Concon, Chile

Covers the History

To the Editor:

I have been askd to give a speech covering "History of the Natural Gasoline Industry" to the Lions Club of Greggton, Texas. I would appreciate your permission to use "The Natural Gasoline Story" published in the January 1959 (Oil Centennial) issue of PETROLEUM REFINER in the speech as it covers more history than any other source I have located. Our company photographer also needs permission to make slides of some of the pictures in this article.

W. H. Heyland
Natural Gasoline Division
Arkansas Fuel Oil Corp.
Shreveport, La.

"More About Corrosion"

To the Editor:

We should like further information on a brief article under the above heading on page 160 of your journal for June, 1959. We are unable to understand the full significance of the difference between Figures 1 and 2 and should be pleased to receive the reference to the original article by W. H. Sharp and E. W. Haycock, if it has been published.

David T. Rigden
Kwinana, West
Australia

Editor's Reply

You are quite right in that we failed to identify the basis of these curves which confused you as a reader. Figure 1 is the predicted long-term corrosion rates of low-chromium steels as a function of temperature and hydrogen sulfide pressure, while Figure 2 represents the predicted long-term corrosion rates of 18 Cr-8 Ni stainless steel as a function of temperature and hydrogen sulfide pressure.

We are sure that you could obtain a copy by writing to the Publications Department, American Petroleum Institute, 50 West 50th Street, New York 20, New York. The paper was presented at the 24th Meeting of the API Division of Refining, New York, May 27, 1959, with the full title "Sulfide Scaling Under Hydrorefining Conditions."

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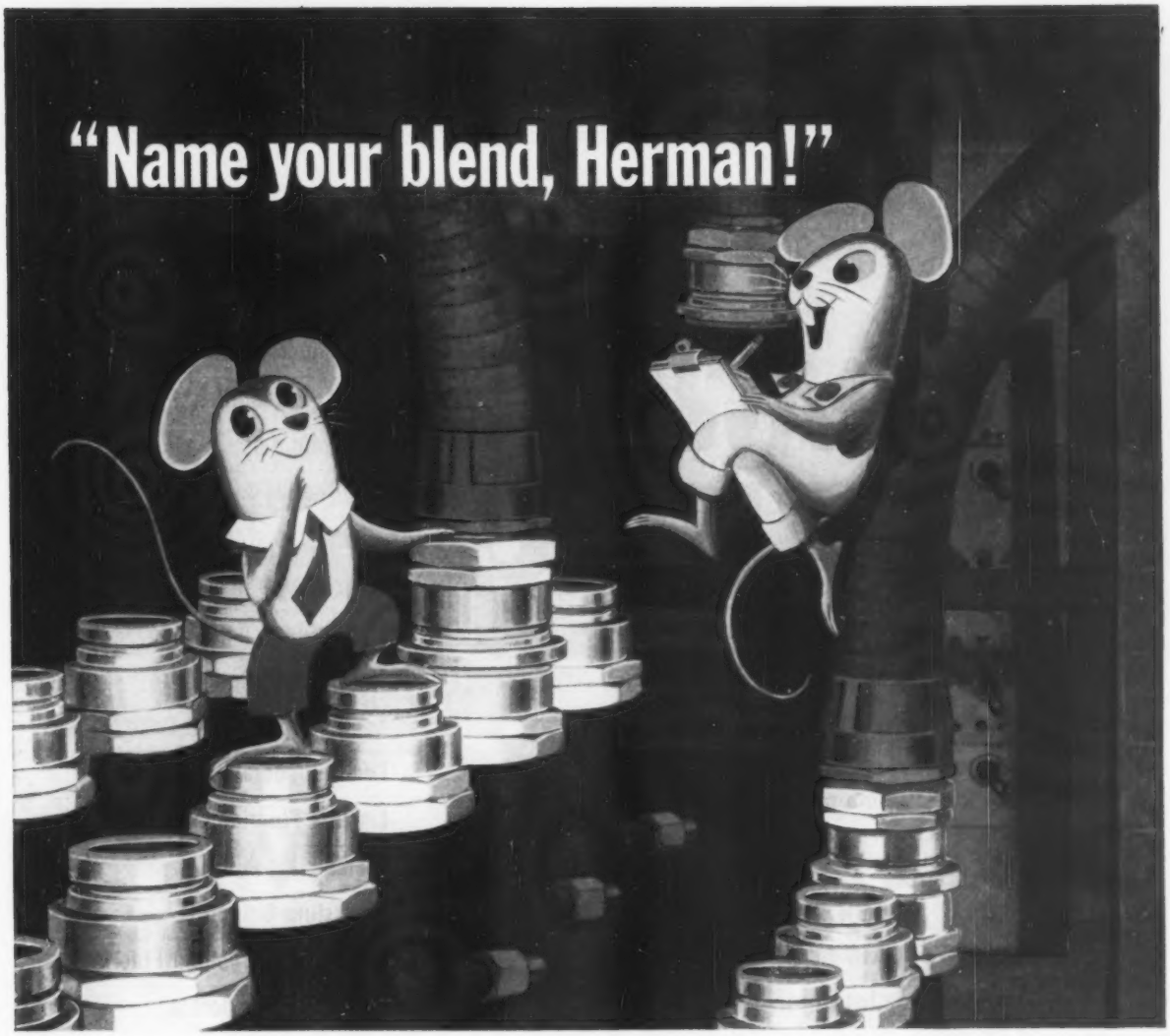

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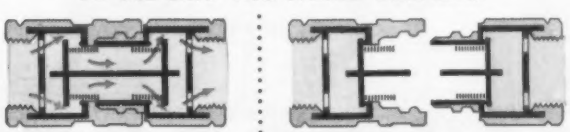

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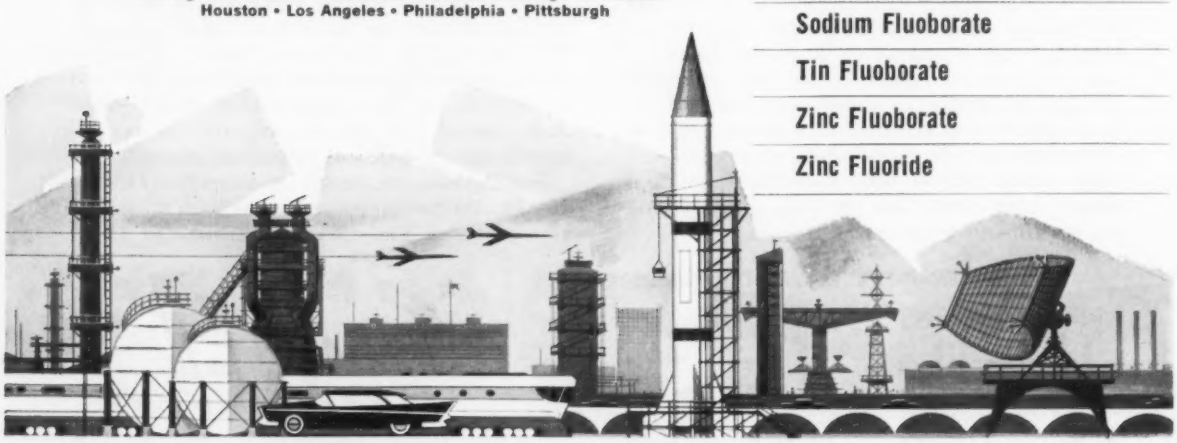

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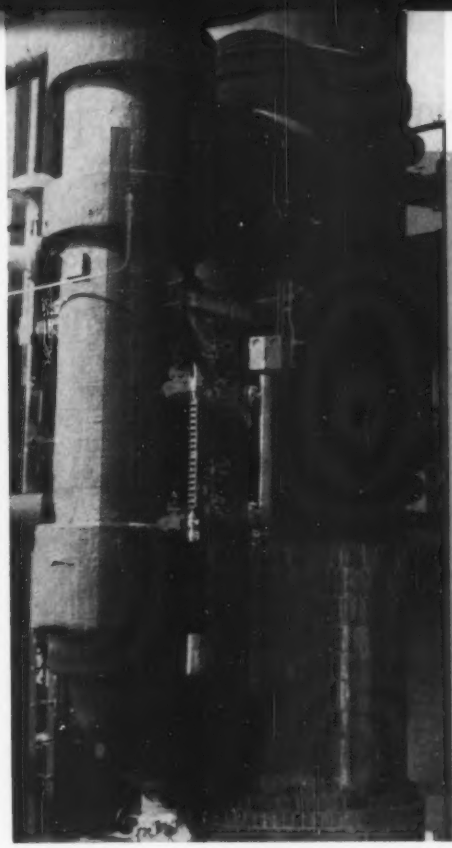

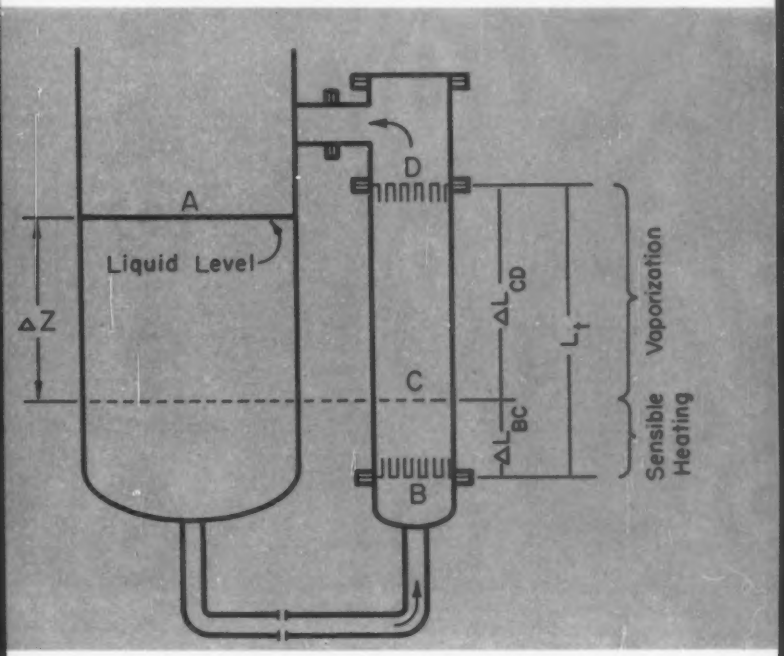

FIGURE 1—Design procedures dealing with vertical thermosiphon reboilers also apply to other types of vertical reboilers.

What You Need to Design Thermosiphon Reboilers

- **Method gives more reliable design of thermosiphon reboilers**
- **Some principles apply also to other types of reboilers**
- **Step-by-step procedure makes for easier job of designing**

James R. Fair
Monsanto Chemical Company
Dayton, Ohio

HERE IS A METHOD for designing vertical thermosiphon reboilers based on semi-empirical correlations of experimental data. The method may be extended easily to once-through natural circulation and forced-circulation reboilers.

The rational, systematic development of this method permits the designer to predict the performance of reboilers in a fashion much more reliable than previously possible. On the basis of comparative commercial data, heat transfer coefficients may be predicted within an accuracy of $\pm$ 30 percent.

The scope of the article is limited to thermosiphon reboilers in which the process fluid flows inside vertical tubes. This limitation is imposed primarily for conven-

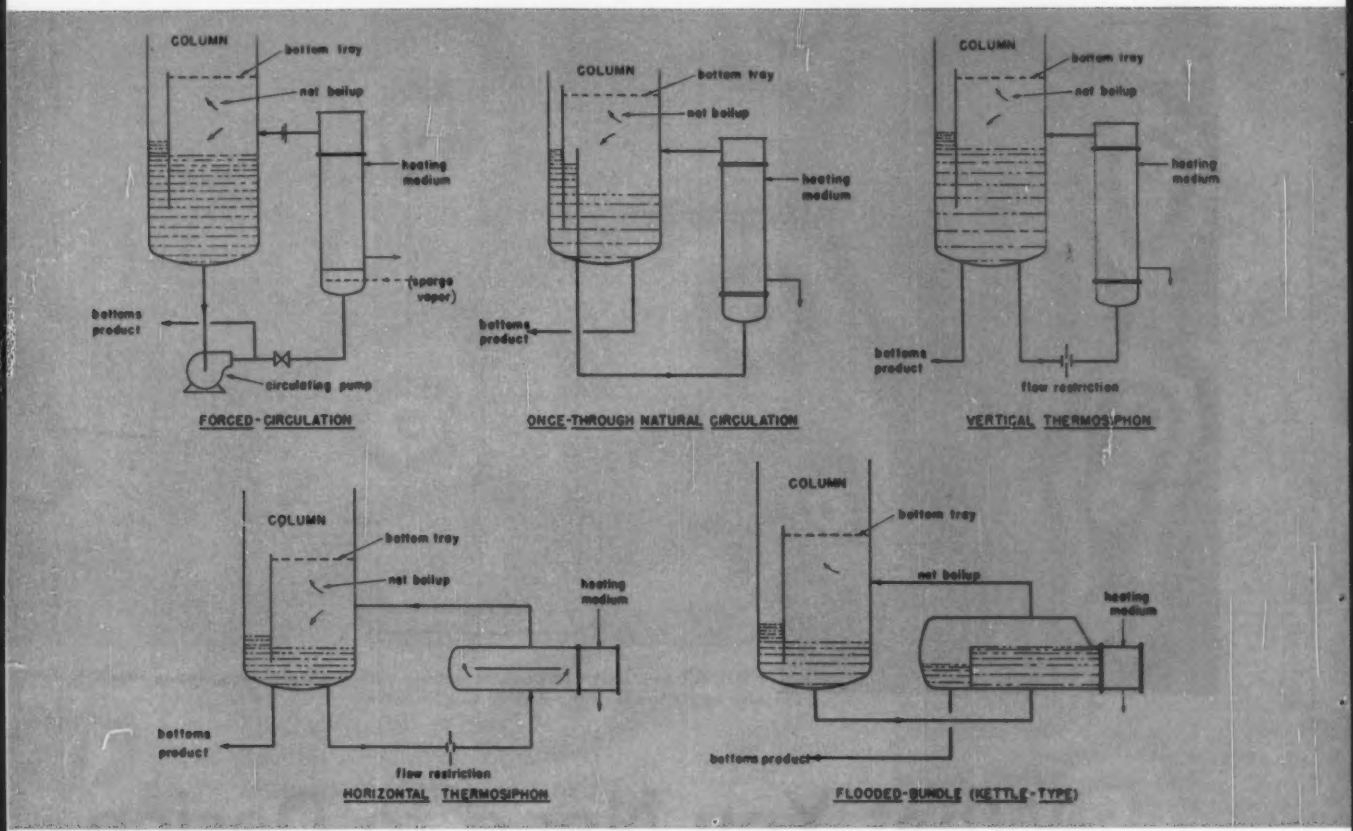

FIGURE 2—Several types of reboilers are used in the natural gasoline, refining and petrochemical industry.

ience in exposition, since different reboiler orientations require different approaches to design. However, material dealing with vertical thermosiphon reboilers also applies to other types of vertical reboilers. This article, then, has broader application than the title might imply.

A few words of caution should be injected at this point. The complex fluid flow and heat transfer phenomena occurring in reboilers are not yet completely understood. A great deal of research is being devoted toward better understanding, but certain empirical correlations will be necessary for many years to come. Any unified procedure which is directed toward practical plant design or operation runs the risk of oversimplification in the mind of the designer. It is hoped that the reader will keep this thought before him as he follows the developments of this article.

PRELIMINARY DESIGN

As is the case for many chemical engineering calculations, heat exchangers must be designed by trial-and-error methods. A given heat exchanger is selected or assumed, and is then checked in detail to ascertain its suitability for the required service. For designs of new equipment, the trial process continues until the optimum arrangement of heat transfer surface is attained. For designs involving equipment already on hand, the trial process is shorter in that equipment variables are fixed.

Reboiler Type. The first step in the trial-and-error design procedure is the selection of reboiler type. In the chemical and petroleum industries the most common reboiler types are:

- Vertical thermosiphon
- Horizontal thermosiphon
- Once-through natural circulation
- Flooded-bundle (Kettle type)
- Forced circulation

These types of reboilers, together with schematic piping arrangements, are shown in Figure 2.

Modifications of the type shown will be evident; for example, forced-circulation reboilers are not necessarily in vertical orientation. Furthermore, internal (calandria) reboilers are not included, since they are rarely used in modern commercial scale design.

Each of the types of reboiler has its special advantages, and there is no set order of choice. Features which should be considered in choosing a reboiler type include:

- Transfer rate (minimum area)
- Space and piping requirement

TABLE 1—Characteristics of Reboilers

Type	Advantages	Disadvantages
Vertical Thermosiphon	Capable of very high heat transfer rates. Compact; simple piping required. Low residence time in heated zone. Not easily fouled. Good controllability.	Maintenance and cleaning can be awkward. Additional column skirt required. Equivalent to theoretical plate only at high recycle.
Horizontal Thermosiphon	Capable of moderately high heat transfer rates. Low residence time in heated zone. Not easily fouled. Good controllability. Easy maintenance and cleaning.	Extra piping and space required. Equivalent to theoretical plate only at high recycle.
Once-Through Natural Circulation	Capable of moderately-high heat transfer rates. Compact; simple piping required. Low residence time in heated zone. Not easily fouled. Equivalent to theoretical plate.	Maintenance and cleaning can be awkward. Additional column skirt height required. No control over circulation rate. Danger of backup in column. Danger of excessive per-pass vaporization.
Flooded-Bundle (Kettle)	Easy maintenance and cleaning. Convenient when heating medium is dirty Equivalent to theoretical plate. Contains vapor disengaging space.	Lower heat transfer rates. Extra piping and space required. High residence time in heated zone. Easily fouled. Relatively expensive due to extra shell volume.
Forced Circulation*	Viscous and solids-containing liquids can be circulated. Enables an erosion-fouling balance Circulation rate can be controlled	Cost of pump and pumping. Leakage of material at stuffing box.

* Advantages and disadvantages will in general correspond to the type of reboiler to which forced circulation is applied. The advantages and disadvantages shown are in addition.

TABLE 2—Preliminary Design Resistances
Basis: Pressures used in commercial fractionations

Heating Side, r_p'	Clean	Service
Condensing steam	0.0005	0.0010
Cooling hot water	0.0025	0.0045
Cooling hot oil	0.0080	0.0100
Combustion gases	*	*
Boiling Side, r_h'	**Clean**	**Service**
C_2–C_4 hydrocarbons	0.0030	0.0040
Gasoline and naphthas	0.0050	0.0060
Aromatics	0.0030	0.0040
C_2–C_7 alcohols	0.0030	0.0040
Chlorinated hydrocarbons	0.0040	0.0070
Water (atm. pressure)	0.0015	0.0025

* For direct-fired reboilers, estimate area on basis of heat flux:
Radiant zone $q/A = 10{,}000$ Btu/(hr)(ft²)(° F)
Convection zone $q/A = 3{,}500$ Btu/(hr)(ft²)(° F)

- Ease of maintenance
- Fouling tendency
- Process fluid residence time
- Operating stability
- Operating cost
- Vapor enrichment

Advantages and disadvantages of the reboiler types with respect to these criteria are summarized in Table 1.

The table is intended to serve as a guide for preliminary planning only; the judgment and experience of the designer may place different emphasis on some of the relative comparisons.

This article applies strictly to the vertical thermosiphon reboiler (with in-tube boiling) only. Sufficient information is provided, however, to enable design of vertical once-through natural circulation reboilers and vertical forced circulation reboilers.

Heating Medium. Condensing steam is the most common heating medium for reboilers. Other media include:

- Hot water
- Hot oil
- Patented heat transfer media
- Combustion gases

The reader will recognize that a great variety of heating media are used in special cases, e.g., when the fractionator reflux is condensed in the reboiler in vapor recompression ("heat pump") operations.

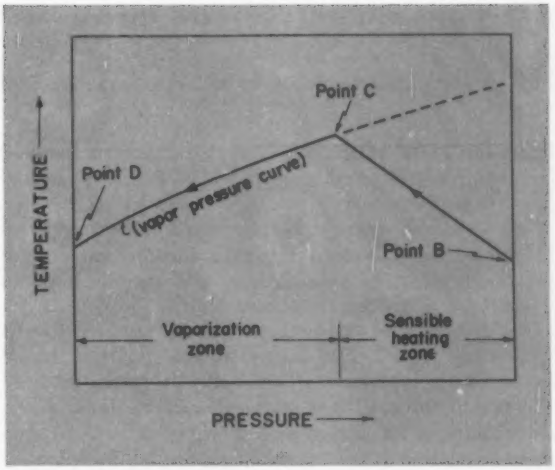

FIGURE 3—The temperature scale is accentuated to show the temperature-pressure effects in reboilers.

Preliminary Transfer Surface. After selections of reboiler type and heating medium have been made, a preliminary estimate of the over-all heat transfer coefficient is necessary. Using the symbols at the end of this article, the familiar equation is as follows:

$$\frac{1}{U} = \Sigma r = r_p + r_{fp} + r_w + r_{fh} + r_h \qquad (1)$$

This equation may be rearranged and shortened for preliminary design:

$$U = \frac{1}{r_p' + r_h'} \qquad (2)$$

where $r_p' = r_p + r_{fp}$
$r_h' = r_w + r_{fh} + r_h$

Values of these combined resistances, based on typical operating data, are given in Table 2. The designer will wish to call on his background or other sources for adapting data such as those found in the table.

Preliminary transfer surface is next calculated by means of the conventional heat transfer equation:

$$A = \frac{q}{U\,\Delta t} \qquad (3)$$

where A and U refer to the process (inside) surface.

Standard heat exchanger tubing dimensions are readily available in handbooks and heat transfer texts. Many companies have standardized on a relatively few combinations of tubing diameter, gage, and length. Within such limits the designer will convert the preliminary transfer surface to a certain number of tubes in vertical orientation.

CIRCULATION RATE

Prediction of the heat transfer rate on the process side of a thermosiphon reboiler is complicated by the fluid dynamics of the system. By definition, "thermosiphon" indicates a movement due to density differences in hot and cold legs of a circulating system. Before the heat transfer rate can be predicted, a pres-

sure balance must be made in order to establish flow rates.

Reboiler Flow Loop. The flow arrangement between fractionator and reboiler is shown in Figure 1. Liquid flows from the reservoir through a feed leg to the base of the reboiler, where it is distributed fairly uniformly to the tubes. The feed leg may include valves and other resistances to flow. It may also include a pump in the case of forced-circulation units.

At the base of the tubes heat is applied to the circulating liquid. The liquid at this point is below its boiling temperature, due both to static pressure effects and to heat losses in the circulating lines. Thus, for a portion of the travel through the tubes only sensible heating takes place. After the boiling point is reached vaporization occurs and two-phase flow regimes are established which add greatly to the complexity of analyzing the pressure balance between feed leg and vaporization leg.

Figure 3 is an idealized representation of the pressure-temperature effects in a thermosiphon reboiler. It should be noted that the temperature scale is accentuated.

For vacuum service, two extreme cases are possible: (a) high-velocity forced-circulation may prevent vaporization from occurring before the liquid re-enters the tower, (b) addition of steam or other inert gas below the bottom tube sheet may provide two-phase flow throughout the tube length.

For thermosiphon reboilers, the designer must strike a balance between the feed leg (from tower reservoir to reboiler) and the vaporization leg (reboiler back to tower). Thus, the amount of vaporization influences the recirculation rate.

For once-through natural circulation reboilers the circulation rate is fixed by the fractionator downflow and reboil ratio; the liquid level in the feed leg adjusts to pressure balance requirements. For forced-circulation reboilers the rate is set by the pump design.

Two-Phase Flow. For dry distillations liquid-vapor flow occurs through the path CDA in Figure 1. For distillations with an inert carrier, the gas (usually steam) frequently is sparged below the bottom tube sheet and liquid-gas flow occurs through the path BCDA. Some understanding of this two-phase phenomenon is necessary for reboiler design.

The concurrent flow of gas-liquid systems cannot be described as simply as it can for either phase flowing alone. Description may be empirical, according to mechanism: laminar-laminar, laminar-turbulent, turbulent-laminar, and turbulent-turbulent. The notation refers to the flow mechanism each phase would have if flowing separately through the conduit. For vertical flow in reboiler tubes, the two-phase mechanism is generally turbulent-turbulent. It should be apparent that such designations are arbitrary, and useful only for correlating purposes.

Two-phase flow is more generally described according to flow pattern. Such patterns are based on visual observations and for a horizontal pipe may take the following forms:

- Bubble flow
- Plug flow
- Stratified flow
- Wavy (or cresting) flow
- Slug flow
- Annular flow
- Mist flow

These patterns are fairly self-descriptive, but for further information the papers of Alves,[2] Baker[3, 4] and Gresham, *et al*[17] should be consulted.

For vertical flow, only four of the flow pattern types have been observed. In order of increasing vaporization (i.e., from bottom to top of the reboiler tube), the patterns are arranged:

$$\text{bubble} \rightarrow \text{slug} \rightarrow \text{annular} \rightarrow \text{mist}$$

In the majority of reboiler cases, slug flow predominates (the familiar "percolating" coffee pot is an example), and a few remarks on this pattern are in order.

Coalescence of bubbles into slugs or "pistons" of gas is rapid once boiling begins. The slugs of gas accelerate more rapidly than the remaining liquid and create "slippage" between phases. Gravity effects cause some of the liquid to tumble backward, with the result of fluctuating flow and pressure drop effects. Although each tube undergoes such transient operation, the combined effect of many tubes results in a fairly steady reboiler exit condition. At the exit, however, vapor has a higher velocity than does the liquid. Net liquid holdup and differential phase velocities must be considered in designing the reboiler flow loop.

Annular flow, mist flow, and their transition regime must also be considered when fractional vaporization across the reboiler is high. The mist flow pattern should be avoided, since the gas phase is continuous and heat transfer rates correspondingly low.

Further reference to vertical flow phenomena may be made to the papers by Bergelin,[5] Galegar,[14] Govier[15, 16] Gresham,[17] Dengler[11] and their various coworkers. Baker[3] has developed a generalized method for predicting flow pattern, but transitions between patterns are so indistinct and poorly understood that such a correlation can be approximate only.

Pressure Drop, Inlet Leg. With reference to Figure 1, a mechanical energy balance between points A and B is:

$$dP_{in} + \rho_L \frac{g}{g_c} dZ + \rho_L \frac{V_L}{g_c} dV_L + \rho_L \frac{g}{g_c} dW_S + \rho_L dF = 0 \quad (4)$$

where P = pressure, lbs_f/ft_2
Z = height, ft
V_L = liquid velocity, ft/sec
W_S = shaft work done by system, ft liquid
F = friction loss, (ft) $(lbs_f)/lb_m$

and other terms are conventional in pound-foot-second units. Changes in liquid velocity are normally considered under frictional effects; thus, $dV_L = 0$. The friction loss term is evaluated by the Fanning equation:

$$dF = \frac{4f_L V_L^2 \rho_L}{2 g_c D_i} dL \quad (5)$$

where f_L = Fanning friction factor ($4f_L$ = Blasius friction factor used in the Moody[32] charts) and other terms are conventional.

Integration of Equation 4 and substitution of Equation 5 yield:

$$\Delta P_{in} = P_B - P_A = \rho_L \frac{g}{g_c} \Delta Z - \rho_L \frac{g}{g_c} \Delta W_s - \frac{4 f_L V_L^2 \rho_L \Delta L_i}{2 g_c D_i} \quad (6)$$

which is the basic design equation for the inlet leg. Note that $\Delta W_s = 0$ except in the face of forced circulation reboilers.

Pressure Drop, Outlet Leg. Between points B and A (Figure 1), Equation 4 again applies. Here, $dW_s = 0$, but $dV_L \neq 0$. Also, physical properties concern a two-phase mixture. The integrated equation is:

$$\Delta P_{out} = P_A - P_B = \underbrace{-\frac{g}{g_c}\int \rho_{tp}\, dZ}_{\text{static head loss}} \underbrace{-\frac{1}{g_c}\int \rho_{tp} V_{tp}\, dV_{tp}}_{\text{acceleration loss}} \underbrace{-\int \rho_{tp}\, dF}_{\text{friction loss}} \quad (7)$$

Since the two-phase properties vary throughout the reboiler, Equation 7 does not integrate as simply as Equation 4. The three terms of Equation 7 will be considered separately in the following sub-sections.

Static Head Loss. With reference to Figure 1, the static head effect between elevations at C and D governs thermal circulation. In the outlet leg the density varies with vaporization and the equation

$$-\Delta P_{static} = \frac{g}{g_c}\int \rho_{tp} dZ \quad (8)$$

cannot be integrated directly. The two-phase density ρ_{tp} is defined as

$$\rho_{tp} = \rho_g R_g + \rho_L R_L \quad (9)$$

and $R_L (= 1 - R_g)$ is the volumetric fraction of liquid at any point along the reboiler tube.

Because of slippage effects, R_L is not a simple function of the weight fraction of vapor. To correlate R_L, as well as other properties to follow, it is convenient to introduce the parameter X_{tt}:

$$X_{tt} \equiv \left(\frac{W_L}{W_g}\right)^{0.9} \left(\frac{\rho_g}{\rho_L}\right)^{0.5} \left(\frac{\mu_L}{\mu_g}\right)^{0.1} \quad (10)$$

$$= \left(\frac{1-x}{x}\right)^{0.9} \left(\frac{\rho_g}{\rho_L}\right)^{0.5} \left(\frac{\mu_L}{\mu_g}\right)^{0.1} \quad (10a)$$

where the subscript tt refers to the turbulent-turbulent flow mechanism. In many instances X_{tt} is approximately

$$X_{tt} \approx \frac{W_L}{W_g} \left(\frac{\rho_g}{\rho_L}\right)^{0.5} \quad (11)$$

or the familiar flow parameter for bubble-tray and packed column holdup-flooding correlations. The parameter represents a ratio of kinetic energies of liquid and vapor.

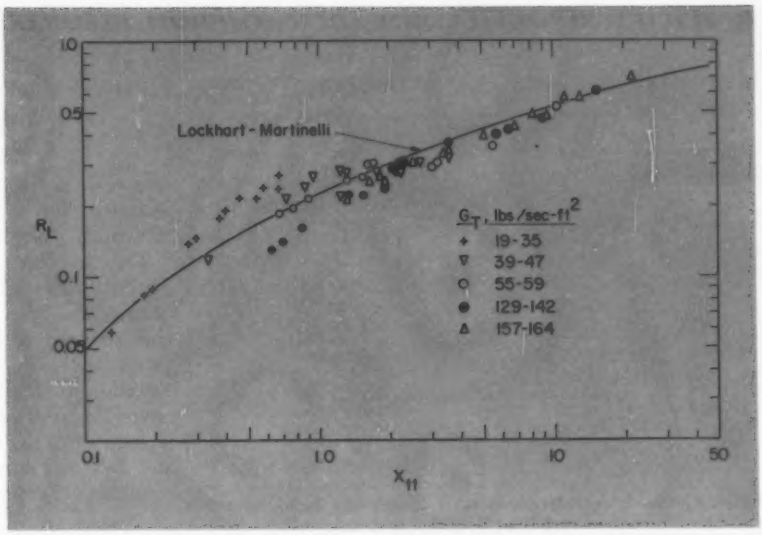

FIGURE 4—The relation of Lockhart and Martinelli fit experimental data very well.[15]

Martinelli and Nelson[29] first introduced the parameter X_{tt} and reported R_L for steam-water as a function of it. Lockhart and Martinelli[28] generalized the R_L vs. X_{tt} relationship for horizontal, small-diameter pipes. Subsequent investigations[11, 14, 15, 22] with vertical tubes have shown fair agreement with the Martinelli correlation when total mass velocities are in the range of interest in reboiler design. All of the work has been with steam or air as the gas phase, and a wide range of pressures has not been covered. Verification of the Martinelli work is sometimes striking, however, as is shown by the recalculated data of Govier[15] superimposed on the Martinelli curve in Figure 4.

Although more experimental data are needed, the curve of Lockhart and Martinelli shown on Figure 4 may be used for design purposes. This curve is reproduced later (Figure 8) as part of the general design procedure.

Acceleration Loss. As vaporization proceeds, there is a conversion of static pressure energy to momentum of the accelerating mixture. The acceleration loss term of Equation 7 is

$$-\Delta P_{acc} = \frac{1}{g_c}\int \rho_{tp} V_{tp} dV_{tp} = \frac{G_T}{g_c}(V_{tp,\,out} - V_{L,\,in}) \quad (12)$$

In the usual case, liquid and gas do not issue from the reboiler with equal velocities. Thus, it is necessary to separate the phase effects in Equation 12:

$$-\Delta P_{acc} = \frac{1}{g_c}\left[\frac{G_L^2}{R_L \rho_L} + \frac{G_g^2}{R_g \rho_g} - \frac{G_T^2}{\rho_L}\right] \quad (13)$$

$$= \frac{G_T^2}{g_c \rho_L}\left[\frac{(1-x)^2}{R_L} + \frac{\rho_L}{\rho_g}\frac{x^2}{R_g} - 1\right] \quad (13a)$$

If the group within brackets in Equation 13a is designated γ,

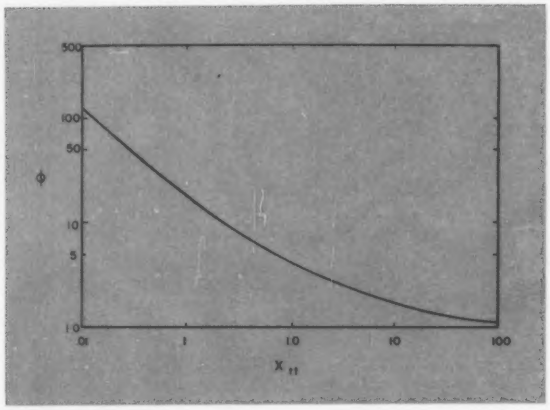

FIGURE 5—A correlation is used to get the factor ϕ for two-phase turbulent-turbulent flow.[28]

$$\Delta P_{acc} = \frac{G_T^2 \gamma}{g_c \rho_L} \tag{14}$$

where γ is evaluated at *outlet* values of x, R_L, and R_g.

Friction Loss. Friction loss in isothermal gas-liquid flow has received much attention by research workers. Comprehensive reviews of the literature have been made,[17, 21] and articles are appearing at the rate of 35-40 per year.[4] Pioneering work in the field was done by Martinelli and co-workers[28, 29] with the generalized correlation of Lockhart and Martinelli emerging as the standard of comparison for subsequent work. Although basically empirical, the Lockhart-Martinelli correlations have enjoyed surprising success in checking later experimental data, particularly for pipe sizes in the range of usual heat exchanger tubing dimensions.

The friction loss term of Equation 7 may be expanded to include the entire path BCDA (Figure 2):

$$-\Delta P_F = -\Delta P_{F,\,B\text{-}C} - \Delta P_{F,\,C\text{-}D} - \Delta P_{F,\,D\text{-}A} \tag{15}$$

Considering length CD, the friction loss term is

$$-\Delta P_{F,\,C\text{-}D} = \int \frac{4 f_{tp} G_{tp} V_{tp}\, dL}{2 g_c D_t} = \frac{G_{tp}}{2 g_c D_t} \int 4 f_{tp} V_{tp}\, dD \tag{16}$$

where f_{tp} = two-phase friction factor (dimensionless), a complex function of type of flow and relative amounts of each phase. If the material were all liquid, the frictional loss would be given by the equation:

$$-\Delta P_F = \frac{G_L V_L}{2 g_c D_t} \int 4 f_L\, dL \tag{17}$$

If Equation 16 is divided by Equation 17, a basic parameter of Lockhart and Martinelli is obtained:

$$\frac{\Delta P_{F,\,tp}}{\Delta P_{F,\,L}} = \frac{\int 4 f_{tp} V_{tp}\, dL}{\int 4 f_L V_L\, dL} \equiv \phi^2 \tag{18}$$

Although not so noted, ϕ properly refers to turbulent-turbulent flow type. This parameter has been correlated against X_{tt} as shown in Figure 5.

The Lockhart-Martinelli correlation will be used in this paper for two reasons: (a) for many investigations it has been shown to hold within ± 30 percent and (b) the correlation parameter X_{tt} is convenient to use in liquid holdup and convective heat transfer correlations. The curve shown in Figure 5 is reproduced later (Figure 9) as part of the general design procedure.

The terms in Equation 15 referring to lengths BC and DA of Figure 1 are handled conventionally. The resulting expression for friction loss in the outlet leg is

$$\Delta P_F = (\Delta P/\Delta L)_L\ (\Delta L_{B\text{-}C}) + \int_C^D (\Delta P/\Delta L)_L\ \phi^2\, dL + \left(\frac{\Delta P}{\Delta L}\right)_{L,\,E} \phi^2_E\, \Delta L_{D\text{-}A} \tag{19}$$

where $(\Delta P/\Delta L)_L = \left(\frac{4 f_L V_L^2 \rho_L}{2 g_c D_t}\right)$ in tubes (20)

and $(\Delta P/\Delta L)_{L,\,E} = \left(\frac{4 f_L V_L^2 \rho_L}{2 g_c D_E}\right)$ at exit (21)

Pressure Balance. For steady-state conditions, the circulation rate is governed by the equality (see Figure 1)

$$\Delta P_{in} = P_B - P_A = -\Delta P_{out} \tag{22}$$

Substituting values from Equations 6, 7, 8, 14, and 19, the primary design equation is obtained:

$$-\rho_L \frac{g}{g_c} (Z_C - Z_D) - \rho_L \frac{g}{g_c} \Delta W_S - \frac{4 f_{L,\,i} V_{L,\,i}^2 \rho_L \Delta L_i}{2 g_c D_i} = \frac{g}{g_c} \int_C^D \rho_{tp}\, dZ + \frac{G_T^2 \gamma}{g_c \rho_L} + \frac{\rho_L}{2 g_c D_t} \left[(4 f_L V_L^2 \Delta L)_{BC} + \int_C^D 4 f_L V_L^2 \phi^2\, dL \right] + \frac{4 f_{L,\,E} V_{L,\,E}^2 \rho_L \phi^2_E \Delta L_{DA}}{2 g_c D_E} \tag{23}$$

This equation is completely rigorous and is suited for stepwise integration across the reboiler tubes from B to D. For such a calculation it is convenient to use increments of fractional vaporization with the relationship

$$x = f(L)$$

established by heat transfer calculations. Such a computation is readily adaptable to digital computer solution.

An approximate solution to Equation 23 is often satisfactory. The liquid friction factor of f_L varies only slightly across the tube length, and an average value may be used. If *effective* average values of ϕ, ρ_{tp}, and V_L across the two-phase path C-D are then chosen, Equation 23 may be integrated and solved for W_T^2:

$$W_T^2 = \left\{ g a_i^2 \rho_L \left[(\rho_L - \bar{\rho}_{tp}) \Delta Z - \rho_L \Delta W_S \right] \right\} \Big/ \left\{ 2 f_{L,\,i} \frac{\Delta L_i}{D_i} + 2 f_{L,\,t} \left(\frac{a_i}{a_t}\right)^2 \left[\frac{\Delta L_{BC}}{D_t} + \bar{\phi}^2 (1 - \bar{x})^2 \frac{\Delta L_{CD}}{D_t} \right] + 2 f_{L,\,E} (1 - x_E)^2 \left(\frac{a_i}{a_E}\right)^2 \phi^2_E \frac{\Delta L_{DA}}{D_E} + \gamma \left(\frac{a_i}{a_E}\right)^2 \right\} \tag{24}$$

where

$\bar{\rho}_{tp}$ = effective average two-phase density

ϕ^2 = effective average (two-phase) / (liquid-phase pressure drop ratio corresponding to effective average vaporization $\bar{x}$.

a_i/a_t = cross-sectional area ratio, inlet line/total tubes

a_i/a_E = cross-sectional areas ratio, inlet line/exit line

This equation is convenient to use when a stepwise integration is not desirable. For many cases it is sufficient for design purposes, exceptions being where there is a significant percentage change in vapor density across the tubes (i.e., compressible flow).

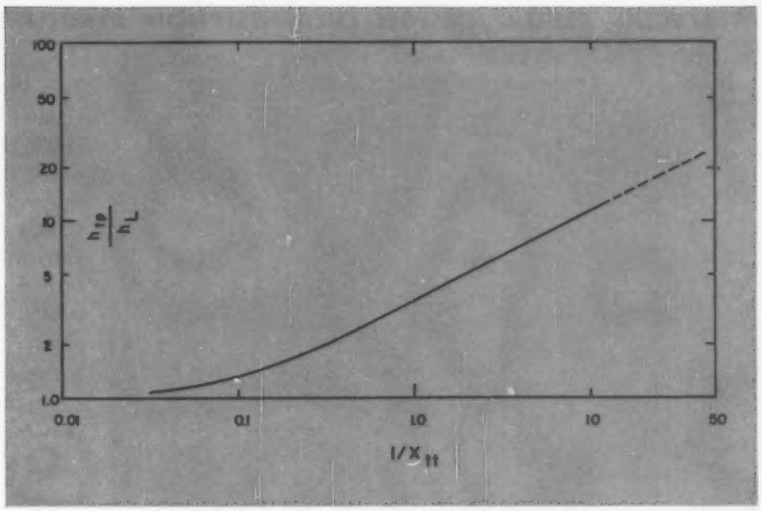

FIGURE 6—A correlation for steam-air was found to apply for heat transfer in two-phase flow of other materials.[11]

Equations 23 and 24 may be regarded as design equations for establishing circulation rate. Equation 24 is convenient for stepwise integrations, with values of x, R_L, ρ_{tp}, and ϕ varying along the tube length. Equation 24 may also be used as a *short-cut design equation,* with its success depending upon proper selection of over-all effective average values. In the absence of specific data the rules given in Table 3 are recommended.

HEAT TRANSFER RATE

For heat transfer calculations it is convenient to consider two zones in the reboiler tube. In the *sensible heating zone* (length B-C in Figures 1 and 3) liquid is brought to the boiling point by single-phase convective transfer; calculations for this zone are straightforward once the circulation rate is established. In the *vaporizing zone* (length C-D in Figures 1 and 3) transfer of heat occurs both by two-phase convective and by nucleate boiling mechanisms. This latter zone poses more difficult design problems.

TABLE 3—Values for Short-Cut Calculation of Circulation Rate (Equation 24)

Value	Definition	Remarks
$\bar{x}$	Two-thirds of outlet fractional vaporization	$\bar{x}=2x_E/3$*
$\bar{R}_L$	Liquid volume fraction based on one-third of outlet fractional vaporization	Figure 7 for $x=x_E/3$*
$\bar{\rho}_{tp}$	Two-phase density based on $\bar{R}_L$	Equation 9
$\bar{\phi}^2$	Pressure drop ratio based on two-thirds the outlet fractional vapor	Figure 8, for $\bar{x}=2x_E/3$*
ΔL_{CD}	Total tube length in which vaporization occurs	.....
ΔZ	Vertical distance in which two-phase flow occurs	Figure 2

* For sparged reboilers where entering $x \neq o$, $\bar{x} = \frac{x_{in} + 2x_E}{3}$, and $\bar{R}_L$ is based on $\bar{x} = \frac{2x_{in} + x_E}{3}$.

TABLE 4—Length of Sensible Heating Zone

Material	Pressure, psia	G_t lbs/(sec)(ft²)	$\left(\frac{\Delta t}{\Delta p}\right)_s$	Fractional Tube Length*	
				$\Delta t=20°$ F	$\Delta t=30°$ F
Water	17	38	3.0	0.31	0.23
	...	150	3.0	0.37	0.28
Benzene	15	38	4.0	0.53	0.43
	...	150	4.0	0.60	0.49
Benzene	132	38	0.75	0.08	0.06
	...	150	0.75	0.11	0.07
n-Butane	145	38	0.57	0.07	0.05
	...	150	0.57	0.09	0.06
n-Butane	268	38	0.36	0.04	0.03
	...	150	0.36	0.05	0.04

* Fraction of total tube length in which sensible heating only occurs.

Sensible Heating Zone. The liquid entering the reboiler tube loses total pressure and gains temperature in the sensible heating zone. The path taken is shown in Figure 3 and is represented by the equation

$$t - t_B = \frac{\Delta t/\Delta L}{\Delta p/\Delta L}(p_B - p) \qquad (25)$$

where t_B and p_B refer to the liquid entering the tubes. The vapor pressure curve may be approximated by

$$t - t_A = (\Delta t/\Delta p)_s (p - p_A) \qquad (26)$$

If $t_A = t_B$ (i.e., no heat loss from tower reservoir), Equations 25 and 26 can be solved simultaneously and rearranged to give

$$\frac{p_B - p}{p_B - p_A} = \frac{\left(\frac{\Delta t}{\Delta p}\right)_s}{\frac{\Delta t/\Delta L}{\Delta p/\Delta L} + \left(\frac{\Delta t}{\Delta p}\right)_s} \qquad (27)$$

which is the fraction of the total available head between points A and B that represents the sensible heating zone. If liquid friction in the sensible heating zone is neglected, and if the liquid level in the tower is maintained even with the top tube sheet, Equation 27 gives the fractional tube length devoted to sensible heating.

The terms of Equation 27 are simple to evaluate. The value of the pressure at the tube inlet is

$$p_B = \frac{(Z_A - Z_B)\rho_L g}{144 g_c} + p_A - \frac{\rho_L \Delta F_{in}}{144} \qquad (28)$$

The slope of the vapor pressure curve $\left(\frac{\Delta t}{\Delta p}\right)_s$ may be es-

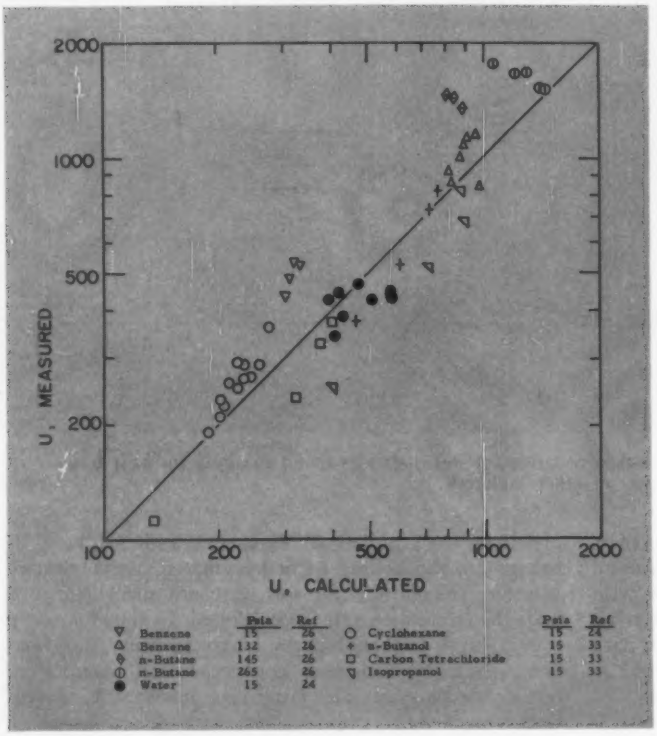

FIGURE 7—The simplified design procedure gives reasonable agreement between measured and calculated coefficients.

timated from thermodynamic tables or calculated from an Antoine-type vapor pressure equation. (Dreisbach[13] is a convenient source for the Antoine constants.) The term $\Delta t/\Delta L$ is obtained from a heat balance:

$$\Delta t/\Delta L = \frac{\pi D_t N_t h_L (t_w - t_L)}{3600\, W_T c_L} \qquad (29)$$

where the heat transfer coefficient is calculated by means of the Dittus-Boelter equation for heating:[30]

$$h_L = 0.023 \frac{K_L}{D_L} \left(\frac{3600\, D_t G_t}{\mu_L}\right)^{0.8} \left(\frac{c_L \mu_L}{k_L}\right)^{0.4} \qquad (30)$$

The term $\Delta p/\Delta L$ in Equation 27 is calculated from the equation

$$-\Delta p/\Delta L = \frac{\rho_L g_c}{144 g} + \frac{\Delta F_{B-C}}{\Delta L} \qquad (31)$$

The second term on the right may usually be neglected. Equation 27, together with Equations 28-31, is convenient for design purposes.

Typical values of the sensible heating zone length are given in Table 4. At higher pressure operation the slope of the vapor pressure curve, $(\Delta t/\Delta p)_s$, is low enough not to influence Equation 27 and most of the tube length is available for vaporization. At the other extreme, in vacuum reboilers a significant portion of the tube length is used for sensible heating and the remaining two-phase leg does not promote rapid thermal circulation.

Two-Phase Convective Transfer. For convective transfer in the vaporization zone, use is made of the correlating parameter X_{tt} introduced earlier (Equation 10). The heat transfer-momentum transfer analogy may be extended to give a two-phase convective heat transfer coefficient, h_{tp}. As in the case of pressure drop, heat transfer to two-phase mixtures is significantly greater than for either phase flowing alone.

Dengler[11, 12] developed the correlation of steam-air data shown in Figure 6. Over much of the range of gas-liquid ratios, the following equation fits the curve:

$$\frac{h_{tp}}{h_L} = 3.5 \left(\frac{1}{X_{tt}}\right)^{0.5} \qquad (32)$$

Although Equation 32 was developed for the steam-water system, it was later shown to apply to vaporizing alcohols and hydrocarbons[18, 35] and to air-water.[25, 38]

The reliability of Equation 32 is related to flow-pattern effects; for bubble and slug pattern it represents experimental data remarkably well. For annular and mist patterns the equation is likely to be optimistic—particularly in mist flow where "dry wall vapor binding" gives low coefficients characteristic of gas-continuous regimes. Such vapor binding can occur at temperature differences significantly below those associated with film boiling; thus optimum circulation rates for a thermosiphon reboiler are limited by gas/liquid ratios.

Equation 32 is based on boiling studies in commercial-scale vertical thermosiphon equipment. It is applicable for design purposes when Equation 30 is used to calculate h_L. Equation 32 should *not* be used when flow has the mist pattern. Tentative limiting values of X_{tt} are given in a design chart, Figure 12, to appear later. Equation 32 is presented in different form in another design chart, Figure 10.

Nucleate Boiling. Boiling heat transfer research studies have in large part dealt with nucleate pool boiling and, above a critical temperature driving force, film boiling. Since heat transfer in a vertical thermosiphon reboiler occurs both by nucleate boiling and by two-phase convective transfer—with the latter mechanism often predominating—it is necessary that the designer not confine himself to the usual limiting criteria of pool boiling. The previously-mentioned flow regimes created by vaporization may be more important than such factors as "maximum heat flux" and "critical temperature difference."

A large volume of literature exists which covers the fundamental aspects of nucleate pool boiling. No attempt here will be made to re-state principles or re-trace developments in the investigation of such boiling phenomena. The reader is referred to standard texts,[23, 30]

TABLE 5—Nucleate Pool Boiling Data

Material	Press. (psia)	EQUATION TERMS* m	n	Δt Range	Max. Δt (°F)	BOILING COEFFICIENT AT DESIGNATED Δt 5 F	10 F	20 F	30 F	40 F	50 F	Heating Device	Ref.
Propane	20—35	46	2.5	7—15	..	(515)	1460	....	....	....	....	HT	31
Propane	170	87	2.0	15—25	50	....	(870)	1740	(2610)	....	....	VT	9
Propane	245	110	2.0	10—30	40	....	1100	2200	3300	....	....	VT	9
Propane	295	145	2.0	10—25	30	....	1450	2900	4350	....	....	VT	9
Propane	375	205	2.0	10—25	25	....	2050	4100	6150	....	....	VT	9
Propane	475	320	2.0	7—15	15	(1600)	3200	....	....	....	....	VT	9
n-Butane	20—35	12	2.64	7—15	..	(170)	525	....	....	....	....	HT	31
n-Pentane	22	$4.5(10^{-4})$	4.70	30—60	60	....	....	....	130	385	850	VT	9
n-Pentane	59	$2.0(10^{-3})$	4.16	20—45	45	....	....	265	850	2350	....	VT	9
n-Pentane	115	0.76	3.27	15—35	35	....	....	695	1700	....	....	VT	9
n-Pentane	215	23.5	2.91	8—20	25	....	1900	7250	....	....	....	VT	9
n-Heptane	6.6	$3.4(10^{-5})$	3.85	50—80	80	....	....	....	....	....	240	VT	9
n-Heptane	14.7	0.60	2.90	30—60	60	....	....	....	380	660	1010	VT	9
n-Heptane	50	2.25	2.90	25—40	40	....	....	....	1450	2480	....	VT	9
n-Heptane	115	9.0	2.75	20—35	35	....	....	1710	3400	....	....	VT	9
n-Heptane	215	107	2.20	15—25	25	....	(1710)	3900	....	....	....	VT	9
Kerosine	14.7	1.79	3.19	10—15	>15	(60)	280	....	....	....	....	HT	10
Benzene	14.7	$4.9(10^{-5})$	3.87	45—90	90	....	....	....	....	(195)	370	VT	9
Benzene	50	$3.4(10^{-4})$	3.87	25—50	50	....	....	....	580	1350	2580	VT	9
Benzene	115	0.77	3.27	15—40	40	....	....	600	1650	3400	....	VT	9
Benzene	265	42	2.61	7—25	25	....	1720	5200	....	....	....	VT	9
Benzene	465	$1.0(10^{8})$	1.96	3—11	11	4800	9400	....	....	....	....	VT	9
Styrene	2.7	11.5	2.05	20—90	..	....	....	270	410	550	700	HP	6
Styrene	14.7	29.0	2.05	20—50	..	....	....	670	1030	1390	1750	HP	6
Methanol	14.7	1.61	3.25	10—15	>15	(120)	290	....	....	....	....	HT	10
Ethanol	14.7	$2.4(10^{-2})$	3.73	40—60	60	....	....	....	....	570	1020	VT	9
Ethanol	55	1.74	3.08	20—40	40	....	....	870	2090	3740	....	VT	9
Ethanol	114	21.5	2.67	10—30	35	....	1010	3160	6350	....	....	VT	9
Isopropanol	14.7	6.0	2.40	10—60	60	....	150	400	690	1050	1440	VT	20,30
n-Butanol	14.7	0.40	3.21	15—30	>30	....	....	230	740	....	....	HT	10
Carbon Tetrachloride	14.7	0.18	2.90	20—40	..	....	....	55	115	200	....	VT	20
Carbon Tetrachloride	14.7	0.73	3.14	15—25	>25	....	(100)	440	....	....	....	HT	10
Acetone	14.7	$7.3(10^{-3})$	3.85	20—40	40	....	....	370	1170	2780	....	HP	7
Methyl Ethyl Ketone	14.7	70	1.84	20—50	50	....	....	850	1200	1550	1850	W	37
Water	14.7	14.3	3.14	5—10	>10	450	2000	....	....	....	....	HT	10
Water	14.7	52	2.35	10—35	35	....	1200	2780	5100	....	....	VT	9
Water	14.7	$1.7(10^{-6})$	4.90	15—35	35	....	....	2000	9600	....	....	W	1
Water	383	605	2.82	5—30	30	1130	4000	14,200	30,000	....	....	W	1
Oxygen	14.7	4.8	2.47	6—10	>10	....	140	....	....	....	....	VT	19
Nitrogen	14.7	1.9	2.67	6—12	>12	....	90	....	....	....	....	VT	19
Freon-12	60	0.49	3.82	12—20	>20	....	(320)	2250	....	....	....	HT	31

* Equation: $q/A = m\,(\Delta t)^n$ where $\Delta t = t_w - t_b$, °F.
Notation: VT = Vertical tube
HT = Horizontal tube
HP = Horizontal plate
W = Wire

and especially to the recent and excellent reviews by Westwater.[39]

Below the point of maximum heat flux, as defined by a transition from nucleate to film boiling, film coefficients are generally correlated on the following basis:

$$q/A = m(t_w - t_b)^n \qquad (33)$$

$$h_b = m(t_w - t_b)^{n-1} \qquad (34)$$

where m and n are roughly constant and characteristic of the material being boiled, the system pressure, and the nature of the heat transfer surface. Attempts to generalize boiling coefficients have not been particularly successful.

A tabulation of nucleate boiling experimental data is presented in Table 5. This is not an exhaustive tabulation, nor does it include data on mixtures. Table 5 is intended to serve as a guide for establishing nucleate boiling coefficients on the following bases:

- Mixtures have coefficients intermediate between those of the pure materials
- Coefficients for materials where data are lacking are estimated *relative* to those for which data are available
- Variations in surface conditions and system pressures are properly taken into account.

For designs involving materials not studied experimentally, useful empirical equations are those of Insinger and Bliss:[20, 23]

$$h_b = (\text{const.})\left(\frac{k_L c_L}{\sigma \rho_g}\right)^{1.6} \frac{\rho_L^{2.6}(t_w - t_b)^{2.1}}{\lambda^{0.85}} \qquad (35)$$

and Levy[27]

$$h_b = \text{const.})\frac{k_L c_L \rho_L^2}{\sigma T_b(\rho_L - \rho_g)}(t_w - t_b)^{2.0} \qquad (36)$$

At the present time, no single equation can be recommended. The equation used should be the one which best fits the experimental data for a similar material.

Temperature differences on the process side should

be kept below the maximum value for nucleate boiling. To estimate this maximum Δt, the equation of Rohsenow and Griffith[34] is convenient (though not extensively tested):

$$(q/A)_{max} = 143\,\rho_g\lambda\left(\frac{\rho_L - \rho_g}{\rho_g}\right)^{0.6} \quad (37)$$

Other correlations of maximum heat flux are available.[1, 9, 30] The critical temperature difference is then obtained from a modification of Equation 35:

$$(t_w - t_b)_{max} = \frac{1}{m}\left(\frac{q}{A}\right)^{1/n}_{max} \quad (38)$$

Additional data on the critical Δt may be found in Table 5.

Combined Film Coefficient. For any point in the

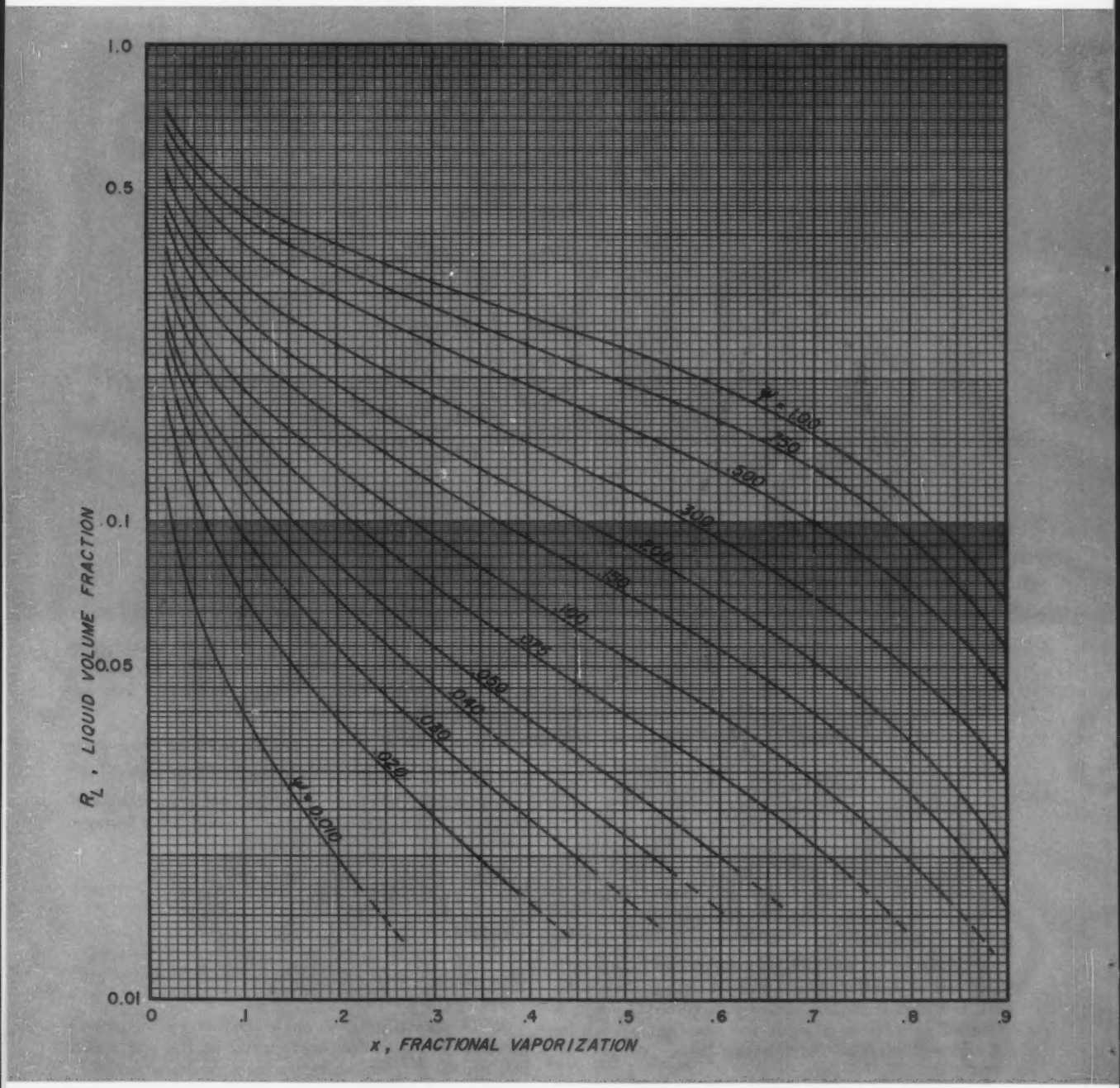

FIGURE 8—Design chart for liquid volume fraction using a parameter defined in Equation 44.

vaporization zone, it may be postulated that the combined boiling-convective heat transfer coefficient is composed of contributions from the two modes of transfer:

$$h_v = \alpha h_b + \beta h_{tp} \quad (39)$$

The empirical constants α and β are obtained from experimental data. For vertical thermosiphon reboilers, convective transfer usually predominates and it is convenient to assign $\beta = 1.0$. (For flooded-bundle reboilers, $\beta \sim 0$.) Then, α may be obtained from experimental data as a residual:

$$\alpha = \frac{h_v - h_{tp}}{h_b} \quad (40)$$

Values of α have been computed from the data of Dengler[11] and Talty[35] in combination with the nucleate boiling data of Cichelli and Bonilla.[9] Values of α vary from 0 to 5 or more. In the early stages of boiling (bubble flow pattern) α has values of at least unity; the velocity effect observed by many workers enhances the pool boiling coefficient. In the slug flow regime, α has values between zero and unity. In the annular flow

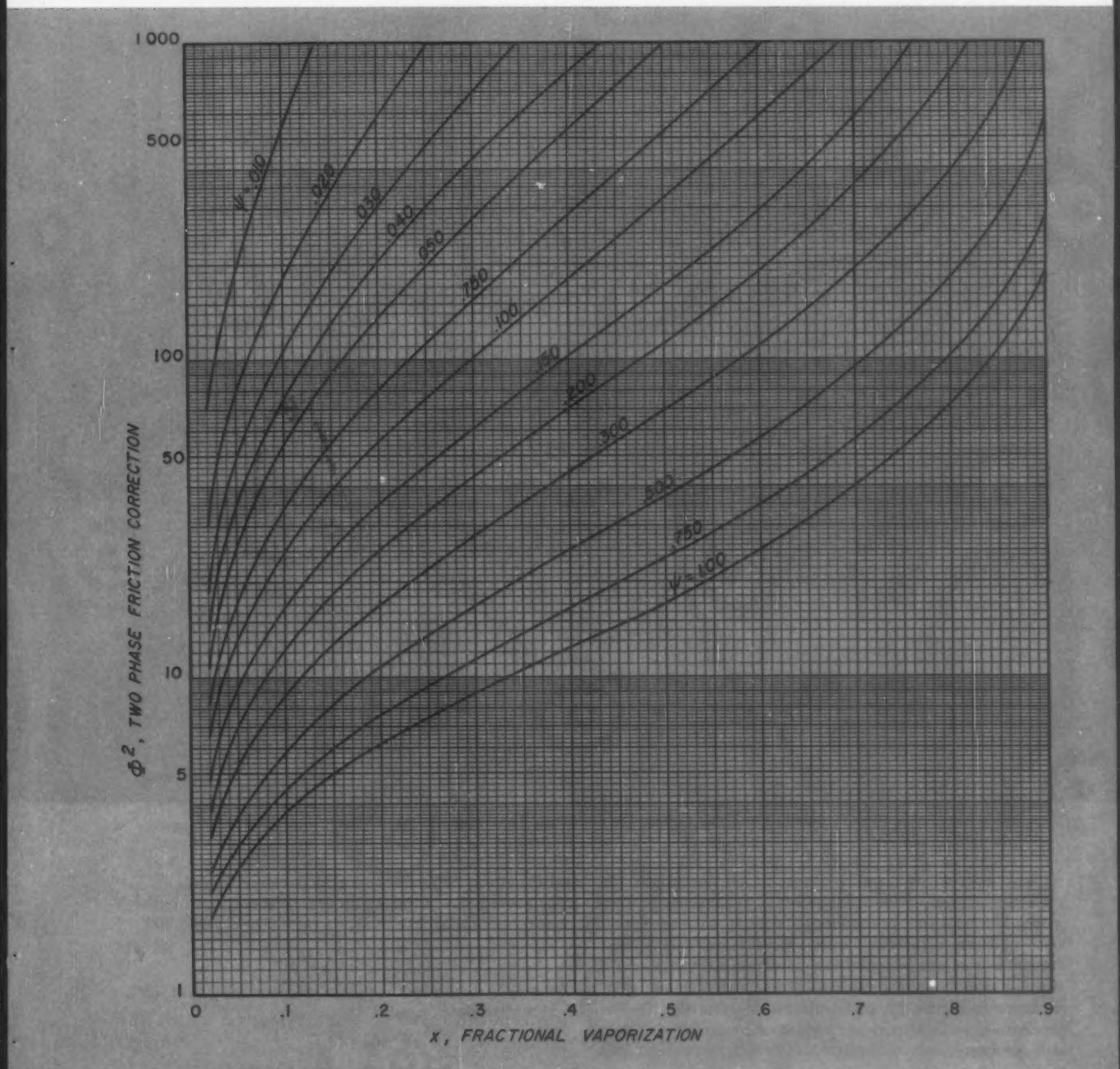

FIGURE 9—Design chart for ϕ^2 values.

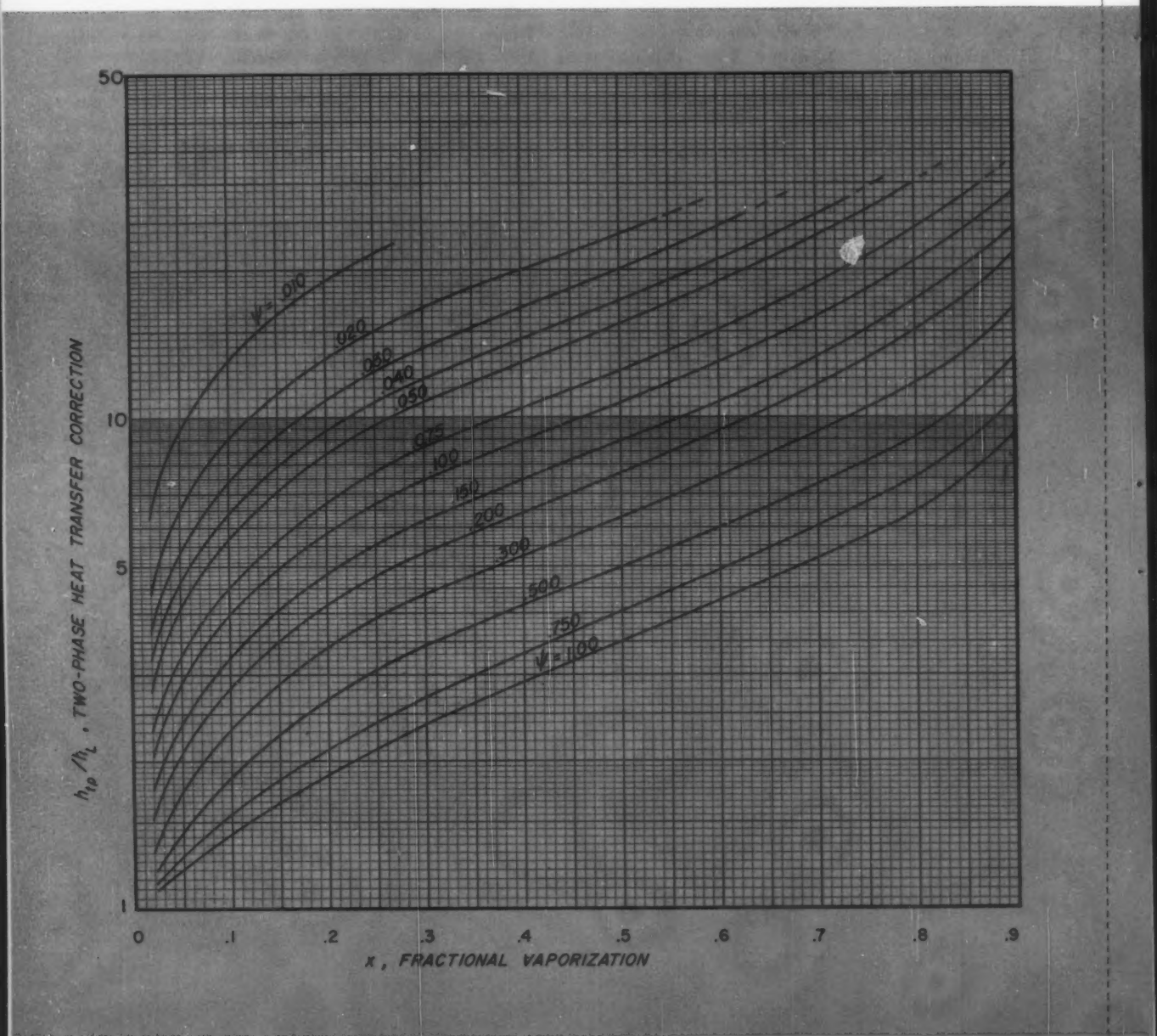

FIGURE 10—Design chart for two-phase heat transfer corrections.

regime, convective transfer alone occurs. As might be expected, scatter of the data is considerable since proper general correlating parameters for flow patterns have not yet been evolved. On the assumption that α decreases in some regular fashion, as vaporization proceeds through the slug flow regime, a design basis has been established. Figure 12, to be discussed under the design procedures section, presents values of α suitable for design purposes.

Rigorous stepwise calculation of heat transfer rates should employ Equation 30 in the sensible heating zone and Equation 39 in the vaporization zone. For short-cut calculations, the following equations should be used.

$$\bar{\alpha} = \frac{\alpha_E + \alpha'}{2} \qquad (41)$$

where α_E is evaluated at exit conditions and α' at 40% of exit vaporization, and

$$\bar{h}_v = \bar{\alpha}\, h_b + \bar{h}_{tp} \qquad (42)$$

where h_b is evaluated for the average inside Δt and $\bar{h}_{tp}$ at 40% of the exit vaporization. The 40% value

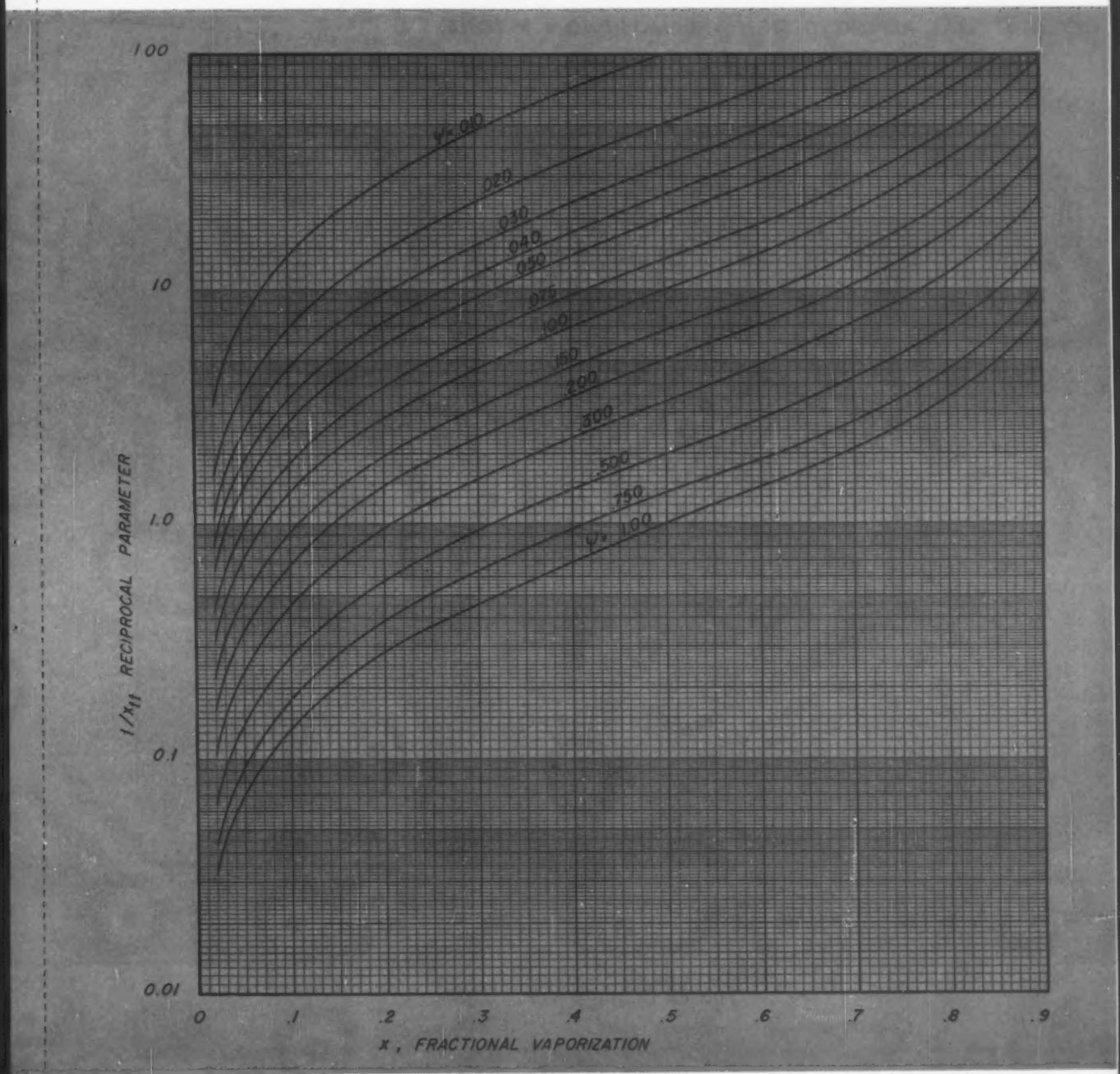

FIGURE 11—Design chart for correlating parameter X_{tt}.

is based on integrations of Equation (32). Finally, the average inside coefficient is calculated as a length-mean average:

$$h_p = \frac{\Delta L_{BC} h_L + \Delta L_{CD} \bar{h}_v}{L_t} \qquad (43)$$

The length designations are clarified by reference to Figure 1.

RELIABILITY OF METHOD

The primary objective of this paper is the development of design procedures for reboiler design. The procedures involve two steps: prediction of circulation rate and prediction of heat transfer rate. The two predictions are related, and ultimate proof of the method must refer to the reliability of the over-all heat transfer coefficient. However, for orientation purposes it is desirable that the designer have some assurance that both flow and heat transfer phenomena are reasonably correct.

Circulation Rate. The only reported study of circulation rates in a plant-scale thermosiphon reboiler was

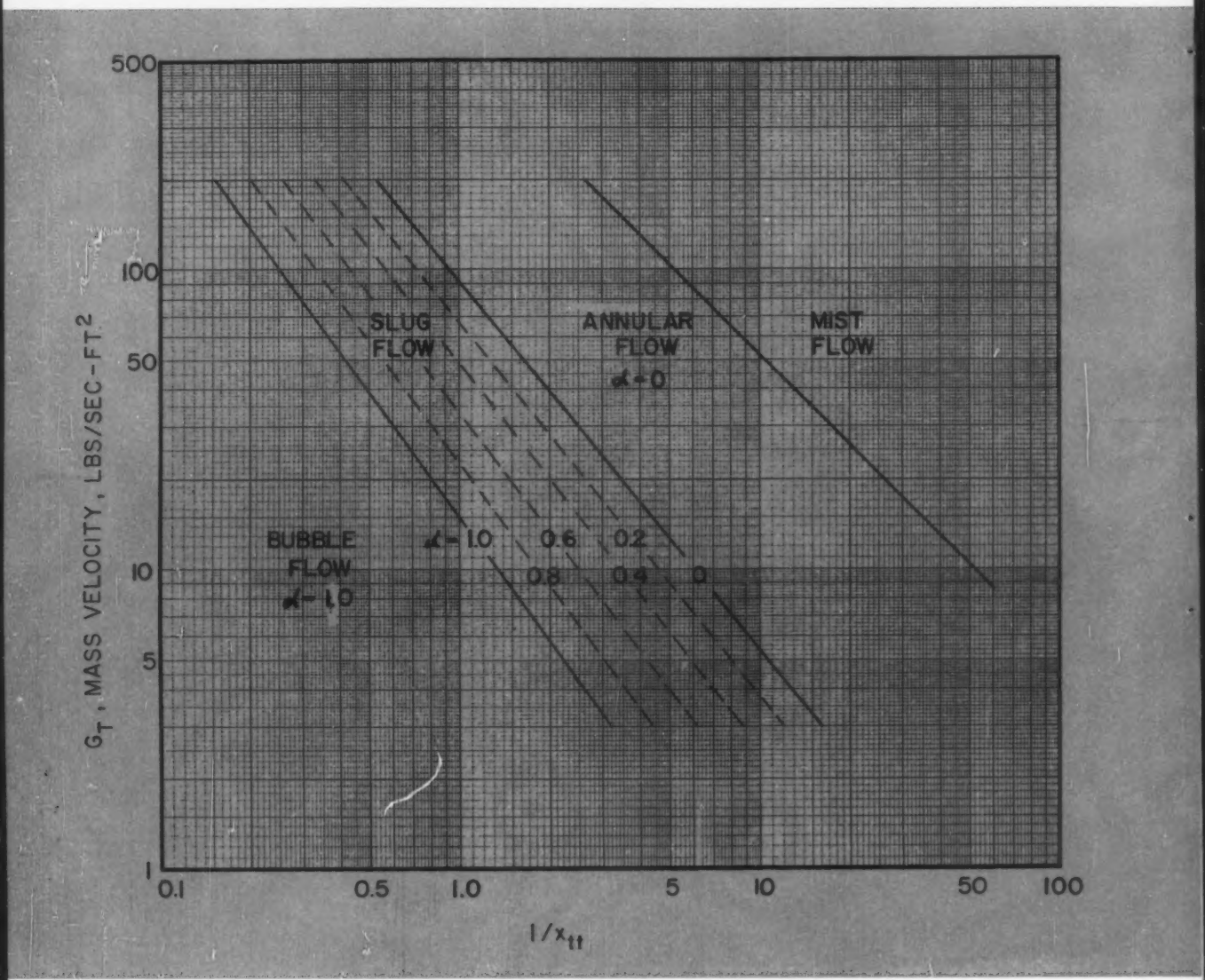

FIGURE 12—Design chart for α values.

made by Johnson.[24] Other flow studies have been in special laboratory equipment[33] or have been associated with semi-empirical evaporator design.

Johnson employed boiling cyclohexane and water, and for some runs a significant flow restriction was placed in the reboiler inlet piping. For some 22 runs in which the vaporization was 5 percent per pass or greater, Equation 24 predicted circulation rates as shown in Table 6 where deviation is referred to the measured value. Equation 24 was used in simplified fashion, i.e., effective average values were used. It appears that the circulation rate is predictable within the ± 30 percent limits set by the Lockhart-Martinelli[28] methods.

TABLE 6—Predicting Circulation Rates

	Cyclohexane	Water
No. runs	12	10
Abs. Avg. Deviation, %	14	22
Max. Deviation, %	35	33

The runs of Johnson in which vaporization per pass was quite low were not reliably predicted by Equation 24—deviations were as high as 80-90 percent. In such extreme cases the calculated value was higher, casting some doubt on the phase holdup correlation (Figure 4) at high values of the parameter X_{tt}. The holdup work of Dengler[12] provides some support to this and suggests higher values of R_L at $X_{tt} > 0.6$.

For normal thermosiphon reboiler design problems, $x_E > 0.05$. Hence, Equation 24 may be used with confidence for predicting circulation rates.

Heat Transfer Rate. The author has found the design procedures described herein to predict quite adequately heat transfer coefficients obtained from plant tests. However, such proof is open to criticism since factors such as fouling deposits, steam side velocity effects, etc., often mask the true boiling side film coefficients. Better proof is available from controlled studies such as those of Johnson,[24] Lee *et al*[26] and Bonnet and Gerster.[8]

Figure 7 shows the results of several calculations in which the simplified design procedure was used. The predicted coefficient compares reasonably well with the measured coefficient, and cases where deviation is large result in conservative design transfer rates. Over-all coefficients included steam-side transfer rates predicted by Nusselt relationships[30] and, in the case of the Lee data, a partial correction for steam velocity.

It may be tentatively concluded that the simplified procedure permits prediction of heat transfer coefficients within ± 30 percent limits of accuracy. Much more quantitative data are needed to confirm these limits, but such a situation is typical of most other areas of heat exchanger design.

In addition to their stated advantages for new design, the procedures offer a means for analyzing the performance of existing equipment. It is believed that the significant variables affecting reboiler operation have been taken into account, and relative effects may be predicted with high reliability.

Use This Easy Design Procedure

To facilitate design calculations, Figures 8-12 have been prepared to give the following information:

Figure 8—R_L values on the basis of Figure 4.

Figure 9—ϕ^2 values on the basis of Figure 5.

Figure 10—h_{tp}/h_L values on the basis of Equation 32, with modification at $1/X_{tt}$ values below 0.2 as suggested by Dengler and Addoms.[12]

Figure 11—$1/X_{tt}$ values for use in Figure 12.

Figure 12—α for correcting the nucleate boiling coefficient.

Flow pattern limits in Figure 12 are based on the data of Govier *et al*,[15] Yoder and Dodge,[40] Dengler,[11] and Baker.[3]

The parameter ψ in Figures 8-11 is defined as

$$\psi \equiv \left(\frac{\rho_g}{\rho_L}\right)^{0.5} \left(\frac{\mu_L}{\mu_g}\right)^{0.1} = \frac{X_{tt}}{(W_L/W_g)^{0.9}} \qquad (44)$$

For cases where there is a significant percentage change in pressure across the reboiler tubes, ψ is not constant. In general, however, an average constant value may be assumed.

Design calculations, as has been pointed out several times earlier, may be made by one of two methods:

- Stepwise calculations along the tube length, using increments of length or vaporization. Increments are chosen small enough that average values of R_L, R_g, ϕ, X_{tt}, h_t, etc., may be used in the difference equations.
- Simplified calculations using average values of variables for the over-all tube length.

Sufficient information is given in this paper to enable the more rigorous stepwise calculations. These calculations are ideally suited to digital computer solution and have been programmed by the author for a machine of the smaller type.

Emphasis in this section will be given to the simplified method, since it is convenient to use and yet sufficiently reliable for most design cases. Thus, designers without ready access to a computer may quickly rate existing reboilers or design new ones.

Process Requirements.

1. From fractionator calculations list
   (a) Boilup rate
   (b) Reboiler outlet temperature, pressure, composition.
2. Obtain physical property data:
   (a) Liquid and gas (vapor) densities, ρ_L and ρ_g
   (b) Liquid and gas (vapor) viscosities, μ_L and μ_g
   (c) Liquid specific heat, c_L
   (d) Liquid thermal conductivity, k_L
   (e) Latent heat of vaporization, λ
   (f) Surface tension, σ
   (g) Slope of vapor pressure curve, $(\Delta t/\Delta p)_s$

Preliminary Design.

1. Select tubing material and dimensions
2. Select heating medium
3. Estimate over-all coefficient U (Table 2)
4. Calculate required surface and tube number.

Circulation Rate

1. Select flow loop geometry
2. Assume exit fractional vaporization, x_E
3. Evaluate sensible heating zone (Equation 27)
4. Obtain average values:
   (a) Two-phase density, $\bar{\rho}_{tp}$, at $x_E/3$
   (b) Pressure drop factor, ϕ, at $2\,x_E/3$
5. Obtain ρ_{tp} and ϕ for exit conditions
6. Calculate circulation rate (Equation 24)
7. Calculate boilup, and check against required value
8. Repeat calculations, adjusting flow loop geometry if necessary, until assumed x_E gives the proper boilup rate.

Heat Transfer—Stepwise Method

1. Choose an increment of vaporization, starting at the end of the sensible heating zone. Use arithmetic average value of x for increment calculations. The circulation rate already obtained on the basis of average conditions should be used for initial calculations.
2. Calculate or obtain values for:
   (a) Two-phase density, ρ_{tp}
   (b) Pressure drop factor, ϕ
   (c) Convective transfer coefficient, h_{tp}
   (d) Boiling coefficient, h_b (Table 5 or other source)
   (e) Boiling coefficient correction factor, α (Figure 12)
   (f) Combined film coefficient, h_v (Equation 42)
   (g) Length of increment, based on h_v
   (h) Static pressure loss (Equation 8)
   (i) Frictional loss (Equation 18)

(j) Acceleration loss (Equation 12)
(k) Total pressure loss

3. Continue stepwise calculations to end of tubes. After pressure loss in exit piping is taken into account, the residual pressure should equal the fixed pressure below the bottom tray in the tower.
4. If the pressures do not match, the calculations are repeated for a different circulation rate. Alternately, the circulation rate may be kept constant and pressure drop contributions (inlet line valve, exit line diameter, etc.) adjusted.
5. After the proper pressure balance-heat transfer relationships are established, the calculations are summarized in connection with other heat flow resistances in the reboiler.

Heat Transfer—Simplified Method

1. The previously-established circulation rate is used, but the exchanger dimensions must be checked for heat transfer. Obtain additional over-all average values:
   (a) Heat transfer coefficient for liquid, h_L
   (b) Heat transfer coefficient for two-phase mixture, $\overline{h}_{tp}$, at $x = 0.4x_E$
   (c) Boiling coefficient correction factors: α' at $x = 0.4\,x_E$ and α_E at $x = x_E$ (Figure 12); $\overline{\alpha}$ from Equation 41.
   (d) Nucleate boiling coefficient, h_b, from Table 5 or other source. (An estimate of the film temperature drop is required.)
2. Calculate the process side heat transfer coefficient, h_p, from Equations 42 and 43.
3. Calculate the total heat transferred to the process fluid and check against the required value. The adjustments required may result in a new exchanger configuration, and hence a new calculation of circulation rate.

Design Comments. These comments are directed to the inexperienced designer, and in general amplify material previously presented. The comments are somewhat random in nature but nonetheless are important considerations in optimum design.

- The thermosiphon reboiler has inherrent instabilities. A valve or other flow restriction in the inlet line helps overcome these instabilities. Adjustment possibilities of a valve also compensate for variations in reboiler duty as imposed by changes in operation of the fractionator.
- For once-through natural circulation reboilers, the liquid backup height is calculated from the pressure balance equation. If this height, plus an allowance for froth, reaches the bottom tray level, flooding of the tower will occur.
- Economic optimum design usually implies high circulation rates though not high enough to give "mist" flow.
- The large fraction of tube length used for sensible heating in vacuum reboilers leaves little density difference for thermal circulation. This fact, plus the frequent need for circulating viscous materials, points toward forced-circulation reboilers for vacuum fractionators.
- For steam distillation columns, it is desirable to sparge the steam uniformly to all reboiler tubes. Since this provides full tube length for two-phase flow, thermal circulation is permitted.
- In reboiler design, film boiling should be avoided. However, such rules-of-thumb as 10-12,000 Btu/(hr)(ft²) maximum heat flux are frequently quite conservative.

Review These Examples

EXAMPLE 1—C_3 SPLITTER REBOILER

A thermosiphon reboiler is to be designed for a fractionator which separates propane as the bottoms product. The conditions below the bottom tray are 401 psia and 164° F. A total of 17,600 lbs/hr vapor is to be produced.

Physical data for propane are:

$\rho_L = 24.80$ lbs/ft³
$\rho_g = 4.40$ lbs/ft³
$\mu_L = 0.157$ lbs/(ft)(hr) or 0.065 cp
$\mu_g = 0.036$ lbs/(ft)(hr) or 0.015 cp
$(\Delta t/\Delta p)_s = 0.24$° F/psi
$c_L = 0.85$ Btu/(lb)(° F)
$k_L = 0.068$ Btu/(hr)(ft)(° F)
$\lambda = 96.9$ Btu/lb
$\sigma = 1.24\ (10^{-4})$ lbs/ft
$\psi = 0.49$

Preliminary Design. Boiling is to be inside ¾″-16 BWG steel tubes 8′-0″ long. Condensing steam at 25 psig is available for heating. From Table 2, an overall coefficient U = 300 Btu/(hr)(ft²)(° F) is expected. For the given duty and a total driving force of 20° F, the inside surface required is 285 ft². This is equivalent to 218 tubes.

Circulation Rate. The inlet line consists of 50 equivalent feet of 4-inch standard pipe. The exit line consists of 50 equivalent feet of 6-inch standard pipe. There is no special flow restriction in the inlet line. Preliminary calculations (Table 4) indicate that essentially the entire surface is in the vaporization zone.

To facilitate trial-and-error work, the following constant terms are calculated:

$$\frac{\Delta L_i}{D_i} = 149.3$$

$$\frac{\Delta L_{CD}}{D_t}\left(\frac{a_i}{a_t}\right)^2 = 5.79$$

$$\frac{\Delta L_E}{D_E}\left(\frac{a_i}{A_E}\right)^2 = 19.31$$

$$g\,a_i^2\,\rho_L\,\Delta Z = 49.5$$

$$h_L = 21.1\,W_T^{0.8}$$

For the first trial, assume 39% vaporization per pass. From Figures 8 and 9 and for $\psi = 0.49$,

x	R_L	ϕ^2	ρ_{tp}	γ
0.13	0.34	—	11.35	—
0.26	—	15	—	—
0.39	0.19	25	8.28	2.02

The circulation rate is calculated by means of Equation 24:

$$W_T^2 = \{ 49.5 (24.80 - 11.35) \} /$$

$$\{ 0.008 (149.4) + 0.012 (0.55) (5.79) (15) + 0.008 (0.37) (19.31) (65) + 0.442 (2.02) \}$$

$$= 162$$

$$W_T = 12.7 \text{ lbs/sec}$$

Now, $(W_T)(x_E) = 12.7 (0.39) (0.60) = 4.95$ lbs/sec vaporized, very close to the required vaporization rate of 17,600 lbs/hr (4.89 lbs/sec). No further adjustment is required at this point.

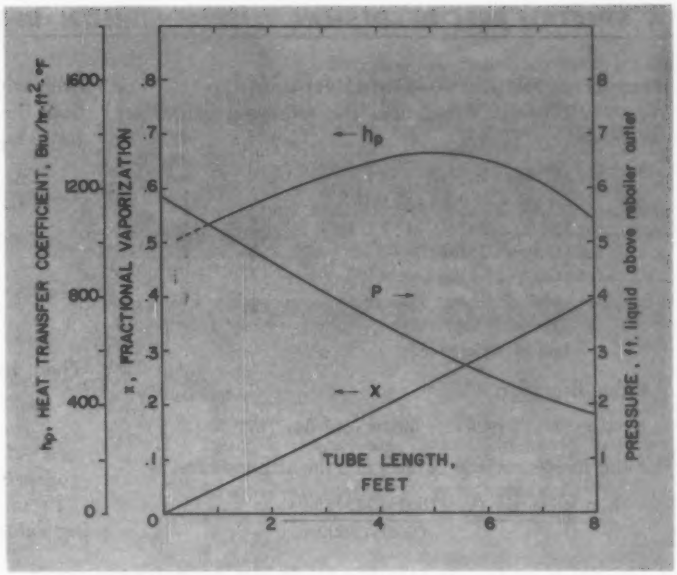

FIGURE 13—Here is a summary of the information found for Example 1.

Heat Transfer Rate—Stepwise Method. Based on the calculated circulation rate of 12.7 lbs/sec., stepwise calculations are carried out for increments of 5% vaporization ($\Delta x = 0.05$). Equations 6, 8, and 19 are used in difference form, based on arithmetic average values of x for each increment. A heat balance is taken over each increment based on the combined film coefficient for that increment. Boiling coefficients from Reference 9 are used.

The calculations are summarized in Table 7 and presented graphically in Figure 13. Several observations may be made:

- The flow patterns are "bubble" and slug"
- The required vaporization is attained in the 8'-0" tube length
- The pressure balance is off by about 21 lbs_f/ft^2. In design this can be corrected by a slight adjustment in liquid level, or by adding pressure drop to the inlet line (e.g., a valve). It will be assumed here that no further trial calculations are needed.

The results of the calculations are:

(a) Total duty = 17,600 (96.9) = 1,705,000 Btu/hr

(b) Average inside coefficient, based on design $t_w - t_b = 5.0°$ F = 1200 Btu/(hr) (ft^2) (° F)

(c) Based on a steam film coefficient of 1500, the *clean* over-all coefficient is 658 Btu/(hr) (ft^2) (° F) on an inside basis.

(d) Including an inside fouling factor of 0.0010 (hr) (ft^2) (° F) Btu and an outside fouling factor of 0.0005 (hr) (ft^2) (° F) Btu,[36] the service over-all coefficient is 331 Btu/(hr) (ft^2) (° F).

(e) The over-all temperature difference is 10-18° F, depending on fouling. Vacuum operation on the steam side is indicated.

TABLE 7—Stepwise Calculations for C_3 Splitter Reboiler Example

Increment	1	2	3	4	5	6	7	8	Exit
Incr. vaporization, Δx	0.05	0.05	0.05	0.05	0.05	0.05	0.05	0.035	.....
Σ vaporization, x	0.05	0.10	0.15	0.20	0.25	0.30	0.35	0.385	0.385
$1/\overline{X_{tt}}$	0.08	0.20	0.35	0.50	0.66	0.83	1.01	1.25	1.32
R_L	0.58	0.42	0.35	0.31	0.28	0.25	0.23	0.20	0.19
ρ_{tp}	16.25	12.98	11.54	10.74	10.08	9.40	9.00	8.60	8.28
ϕ^2	2.70	4.80	7.00	9.60	12.2	15.5	19.0	22.5	25.0
h_{tp}/h_L	1.23	1.65	2.07	2.50	2.90	3.28	3.60	3.95	.....
h_{tp}	198	266	333	403	467	529	580	636	.....
h_b	900	900	900	900	900	900	900	900	.....
$\overline{\alpha}$	1.0	1.0	1.0	1.0	1.0	0.80	.070	0.50	.....
h_p	1098	1166	1233	1303	1367	1249	1210	1085	.....
Incr. length, ft.	1.15	1.08	1.02	0.97	0.92	1.01	1.04	0.81	.....
Σ length, ft.	1.15	2.23	3.25	4.22	5.14	6.15	7.19	8.00	.....
$\Sigma \Delta p$, psf	19.96	35.37	48.56	60.46	71.30	82.72	94.09	102.97	146.57

Pressure Balance

Outlet	psf	Inlet	psf
Static	89.99	Static (8.0 ft)	198.40
Friction, tubes	10.88	Friction, piping	−30.80
Friction, exit	36.30	(Required extra)	−21.03
Acceleration	9.40		
	146.57		146.57

Heat Transfer Rate—Simplified Method. For $W_T = 12.7$ lbs/sec circulation, the following values are obtained:

$h_L = 162$ Btu/(hr)(ft²)(° F)
$h_{tp}/h_L = 2.4$ (at $x = 0.4\ x_E = 0.16$)
$\bar{h}_{tp} = 386$ Btu/(hr)(ft²)(° F)
$\alpha' = 1.0$ } Figure 12, for
$\alpha_E = 0.5$ } $G_T = 27.8$ lbs/(sec)(ft²)
$\bar{\alpha} = 0.75$
$h_b = 900$ Btu/(hr)(ft²)(° F) at $t_w - t_s = 5.0$ ° F and data of Reference.[9]

From Equation 43,

$$h_p = h_v = 0.75\ (900) + 386 = 1061\ \text{Btu/(hr)(ft}^2\text{)(° F)}$$

For the inside surface of 285 ft², the vaporization is

$$\frac{h_p A\,(t_w - t_s)}{\lambda} = \frac{(1061)\,(285)\,(5.0)}{(96.9)\,(3600)} = 4.35\ \text{lbs/sec}$$

The value of the process side coefficient, $h_p = 1061$ Btu/(hr)(ft²)(° F) is lower than the value calculated in a stepwise fashion. A slightly higher value of Δt would correct this.

EXAMPLE 2—CYCLOHEXANE COLUMN REBOILER

A thermosiphon reboiler is to be designed for a fractionator which separates cyclohexane as the bottoms product. The conditions below the bottom tray are 16.5 psia and 182° F. A total of 13,700 lbs/hr vapor is to be produced. Physical data for cyclohexane are:

$\rho_L = 45.0$ lbs/ft³
$\rho_g = 0.200$ lbs/ft³
$\mu_L = 0.97$ lbs/(ft)(hr) or 0.40 cp
$\mu_g = 0.0208$ lbs/(ft)(hr) or 0.0086 cp
$(\Delta t/\Delta p)_s = 3.6$ °F/psi
$C_L = 0.45$ Btu/(lb)(° F)
$k_L = 0.086$ Btu/(hr)(ft)(° F)
$\lambda = 154$ Btu/lb
$\sigma = 1.24\ (10^{-3})$ lbs/ft
$\psi = 0.098$

Preliminary Design. Boiling is to be inside 1-inch-12 BWG steel tubes 8 feet long. Condensing steam at 50 psig is available for heating. From Table 2, and over-all coefficient U = 300 Btu/(hr)(ft²)(° F) is expected. For the given duty and a total driving force of 45° F, the inside surface required is 157 ft². This is equivalent to 218 tubes.

Circulation Rate. The inlet line consists of 100 equivalent feet of 6-inch standard pipe. The exit line consists of 50 equivalent feet of 10-inch standard pipe. There is no special flow restriction in the inlet line.

For the first trial, assume 15% vaporization per pass. This gives a circulation rate of 91,300 lbs/hr or 25.4 lbs/sec. For this rate, the following apply:

$h_L = 161$ Btu/(hr)(ft²)(°F)
$f_{L,i} = 0.0045$
$f_{L,t} = 0.0065$
$f_{L,E} = 0.0045$

It will be assumed that the liquid level is maintained even with the top tube sheet. Neglecting inlet line friction, the sensible heating zone length may be estimated from Equation 27. Terms for this equation are:

$$\frac{\Delta t}{\Delta L} = \frac{3.14\ (0.065)\ (218)\ (161)\ (30)}{3600\ (25.4)\ (0.45)} = 5.2\ \text{°F/ft}$$

(using Equation 29 and assuming $t_w - t_L = 20$° F)

$$\frac{-\Delta p}{\Delta L} = \frac{45.0\ (1.0)}{144} = 0.312\ \text{psi/ft}$$

(neglecting friction in sensible zone)

Then, by Equation 27,

$$\frac{p_B - p}{p_B - p_A} = \frac{3.6}{3.6 + 5.2} = 0.41$$

Hence, length of sensible zone = 0.41 (8.0) = 3.3 ft.

From Figures 8 and 9 and for $\psi = 0.098$, the following values are obtained:

x	R_L	ϕ^2	ρ_{tp}	γ
0.05	0.28	—	12.74	—
0.10	—	25	—	—
0.15	0.16	40	7.37	9.53

The circulation rate is calculated by means of Equation 24:

$$W_T^2 = \left\{(32.2)\,(0.181)^2\,(45.0)\,(45.0 - 12.74)\,(4.7)\right\} \Big/ \left\{0.009\left(\frac{100}{0.336}\right) + 0.013\left(\frac{0.181}{0.320}\right)^2\left[\frac{3.3}{0.065} + 25\left(\frac{4.7}{0.065}\right)(0.90)^2\right] + 0.009\left(\frac{0.181}{0.548}\right)^2 (40)\left(\frac{50}{0.85}\right)(.85)^2 + 9.53\left(\frac{0.181}{0.548}\right)^2\right\}$$

$$= \frac{7{,}200}{2.68 + 6.35 + 1.68 + 1.04} = 615$$

$$W_T = 24.8\ \text{lbs/sec}$$

This value is in reasonable agreement with the assumed value of 25.4 lbs/sec.

Heat Transfer Rate—Simplified Method. For this calculation, the following are obtained:

$h_L = 160$ Btu/(hr)(ft²)(°F)
$\bar{h}_{tp}/h_L = 3.2$ (at $x = 0.4\ x_E = 0.060$)
$\bar{h}_{tp} = 510$ Btu/(hr)(ft²)(° F)
$\alpha' = 0.2$ } Figure 12, for
$\alpha_E = 0$ } $G_T = 66.0$ lbs/sec ft²
$\bar{\alpha} = 0.1$
$h_b = 200$ Btu/(hr)(ft²)(°F) at $t_w - t_s = 30$° F, and benzene data of Reference 9.

From Equations 42 and 43,

$h_v = 0.10\ (200) + 510 = 530$ Btu/(hr)(ft²)(°F)

$$\bar{h}_p = \frac{(3.3)\ (160) + (4.7)\ (530)}{8.0} = 377\ \text{Btu/(hr)(ft}^2\text{)(°F)}$$

For clean conditions, the combined tube wall and steam side resistance is calculated as 0.00090,[30] corrected to inside dimensions. Thus, the calculated U is

$$U = \frac{1}{\frac{1}{377} + 0.00090} = 282\ \text{Btu/(hr)(ft}^2\text{)(°F)}$$

This is close to the assumed value of U. It does not, however, take into account fouling in service. Additional trial designs may be used, or the temperature difference may be adjusted upward.

SYMBOLS USED

a = Cross-sectional area, ft^2
A = Total (inside) surface for heat transfer, ft^2
c = Specific heat, Btu/(lb) (°F)
d = Differential operator
D = Inside diameter, ft
f = Fanning friction factor, dimensionless
F = Friction loss, (ft) (lbs_f)/lb_m
g = Gravitational constant, 32.2 ft/sec^2
g_c = Conversion factor, 32.2 (lbs_m) (ft)/(lb_f) (sec^2)
G = Mass velocity, lbs_m/(sec) (ft^2)
h = Heat transfer coefficient, Btu/(hr) (ft^2) (°F)
k = Thermal conductivity, Btu/(hr) (ft) (°F)
L = Equivalent length of pipe, ft
m = Constant in Equation 33
n = Constant in Equation 33
N_t = Number of tubes
p = Total pressure, lbs_f/in^2 absolute
P = Total pressure, lbs_f/ft^2 absolute
q = Heat transfer rate, Btu/hr
r = Resistance to heat transfer, (hr) (ft^2) (°F)/Btu
r' = Composite resistance to heat transfer, (hr) (ft^2) (°F)/Btu
R = Volume fraction of phase, dimensionless
t = Temperature, °F
T = Absolute temperature, °R
U = Over-all heat transfer coefficient, Btu/(hr) (ft^2) (°F)
V = Linear velocity, ft/sec
W = Mass rate, lbs_m/sec
W_s = Shaft work done by system, ft. liquid
x = Weight fraction of vapor or gas (quality), dimensionless
X_{tt} = Correlating parameter (Equation 10), dimensionless
Z = Vertical height, ft

GREEK LETTERS

α = Correction factor for nucleate boiling, dimensionless
β = Correction factor for convective transfer, dimensionless
γ = Acceleration loss group (Equation 13), dimensionless
ΔP = Pressure loss, lbs_f/ft^2
Δt = Over-all temperature difference, °F
ΔZ = Height of driving leg for thermal circulation, ft
λ = Latent heat of vaporization, Btu/lb_m
μ = Viscosity, lbs_m/(ft) (hr)
π = Constant, 3.1416 . . .
ρ = Density, lbs_m/ft^3
$\bar{\rho}$ = Average density, lbs_m/ft^3
σ = Surface tension, lbs_f/ft
ϕ = Parameter for two-phase pressure loss (Equation 18), dimensionless
$\bar{\phi}$ = Average value of ϕ
ψ = Parameter for two-phase physical properties (Equation 44), dimensionless

SUBSCRIPTS

A = Point A in flow loop (Figure 1)
b = Boiling
B = Point B in flow loop (Figure 1)
BC = Tube length for sensible heating (Figure 1)
C = Point C in flow loop (Figure 1)
fp = Process side fouling
F = Friction
g = Gas phase
h = Heating medium
i = Inlet (feed leg) piping system
L = Liquid phase
m = Mass
p = Process (boiling) side
CD = Tube length for vaporization (Figure 1)
D = Point D in flow loop (Figure 1)
E = Reboiler exit system
f = Force
fh = Heating medium fouling
s = Saturated
t = Tube
tp = Two-phase mixture
T = Total flow
v = Vaporization
w = Tube Wall

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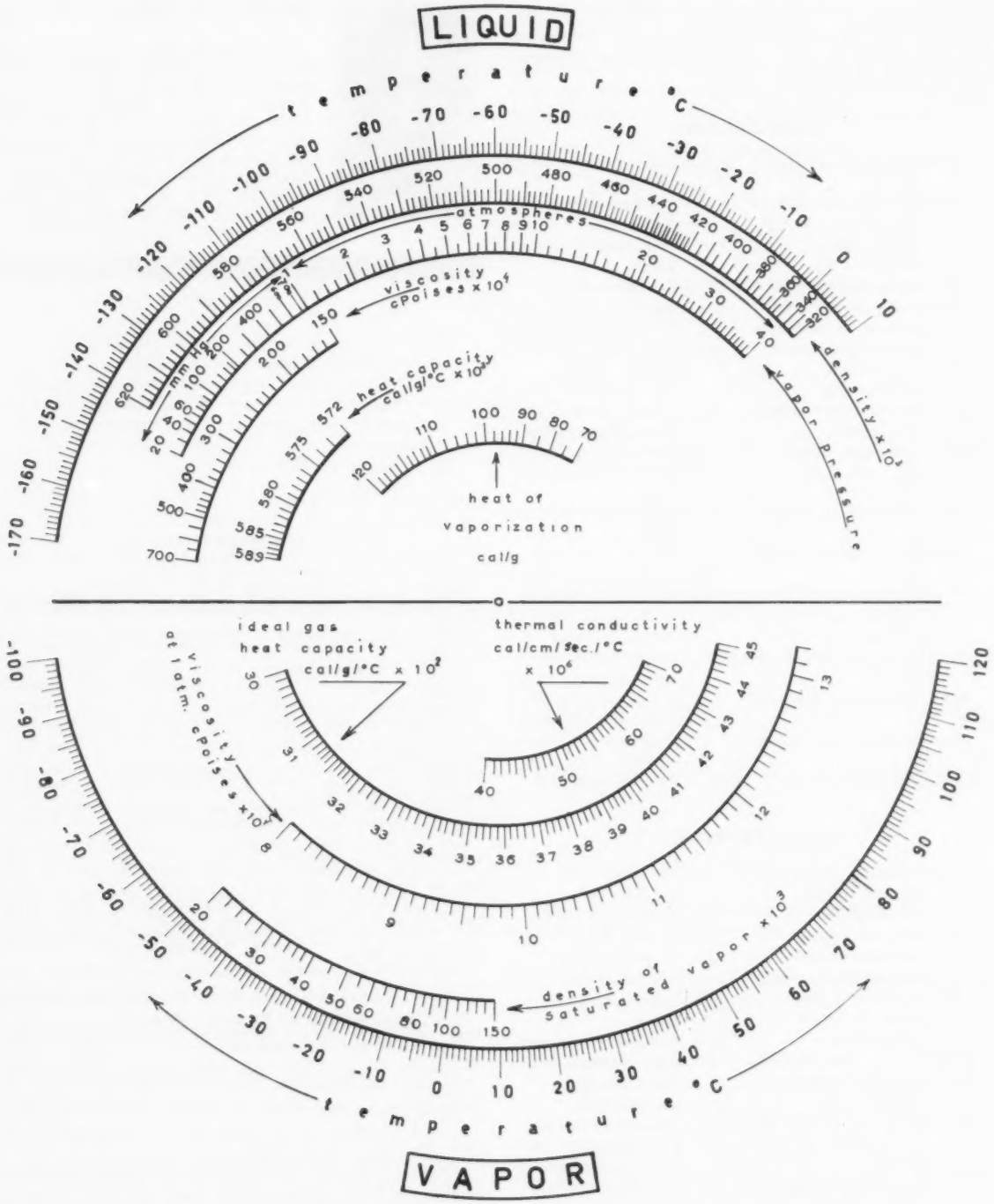

Find Physical Properties of Ethylene

A. M. P. Tans, Staatsmijmen in Limburg
Geleen, Netherlands

THE ACCOMPANYING nomograph has been constructed from literature values. The upper part gives the physical properties of liquid ethylene; the lower part those of the gas. Each part has its own temperature scale. The use of the nomograph is as follows: Any line passing through the center intersects the scales in corresponding points.

Get K-Values by Chromatography

Experimental Ks and activity coefficients determined with a GLPC compare favorably with the NGAA values

Guillermo Lopez Mellado*
Riki Kobayashi, The Rice Institute, Houston

THE APPLICATION of gas-liquid partition chromatography (GLPC) to obtain partition coefficients consistent with static vapor-liquid equilibrium measurements was first established by Porter, Deal, and Stross.[16] The partition coefficient, here denoted by H, is equal to the ratio of the concentration of the solute per unit volume in the solvent phase at peak maximum to the concentration of the solute per unit volume in the gas phase at the peak maximum. The results were exploited in a companion paper[15] to describe and correlate solvent effects in GLPC. Littlewood *et al*[10] introduced the corrected retention volume as a fundamental quantity and obtained heats of solutions from the variation of the retention volumes with temperature.

An expression relating the retention volume and activity coefficients, and a review of the foundations of some empirical relations connected with homologous series was discussed by Herington.[3] Rock[20] reviewed some of the theoretical aspects of GLPC and solution theory and pointed out the relation of GLPC to extractive distillation. Rangel[19] used the expression obtained by Porter *et al*[16] to calculate partition coefficients and obtained K-values for methane and propane in n-decane. Preston[17] used partition coefficients obtained by Kwantes and Rijnders[9] to calculate K-values for light hydrocarbons in other paraffin hydrocarbons.

The use of GLPC to obtain K-values for slightly soluble gases such as methane and ethane requires improvements over the techniques presented here.

RELATIONSHIPS USED TO CALCULATE THERMODYNAMIC PROPERTIES

The Partition Coefficients. Although the corrected retention volume, V_R^o, arises naturally as a result of the theoretical plate treatment of a chromatographic column, retention volume does not depend explicitly on the number of theoretical plates in the column,[8, 10, 11] it has been shown that it depends only on the column characteristics through the following relationship:

$$V_R^o = V_m + H^o V_s \qquad (1)$$

where

V_m = volume of the mobile phase in the column at column conditions,

V_s = volume occupied by the stationary solvent phase in the column, and

$$H^o = \frac{\text{conc. of solute/unit vol. in solv. phase at peak max.}}{\text{conc. of solute/unit vol. in gas phase at peak max.}}$$

when the solute concentrations approach infinite dilution.

Equation 1 may be used to obtain the partition coefficients which serve as a basis for the calculation of other thermodynamic properties provided that:

(a) the coefficients are independent of column characteristic and flow rate,
(b) the coefficients are unaffected by the nature of the solid support, and
(c) the coefficients are in essential agreement with data obtained under well-defined equilibrium conditions.

These conditions were found to be substantially fulfilled for several systems by Porter *et al*[16] who applied Equation 1 to find partition coefficients from corrected retention volumes.

Deviations of the experimental conditions from those set forth by theory and abstract definitions require the following corrections:

(a) The pressure drop through the column. For a compressible fluid, the expression for the retention volume corrected for the pressure drop which was obtained by James and Martin[5] is:

$$V_R^o = \frac{\frac{3}{2} V_R \left[\left(\frac{P_1}{P_o}\right)^2 - 1\right]}{\left[\left(\frac{P_1}{P_o}\right)^3 - 1\right]} \qquad (2)$$

where

P_1 = pressure at inlet to packed section (absolute units)

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P_o = pressure at outlet of packed section (absolute units)
V_R = uncorrected retention volume.

(b) Correction for dead volume of apparatus. The dead volume of the apparatus consists of the volume of the tube leading from the sample injection point to the packed section plus the volume from the end of the packed section to the detector.

(c) Correction for sample volume. The criterion of Van Deemter *et al*[21] for negligible displacement of the peak maximum as a result of sample volume size is that if the sample volumes, A, is less than $0.5\,V_R/\sqrt{n}$, the width of the elution curve becomes almost independent of sample volume. n signifies the number of theoretical plates as determined by the relation of James and Martin[5]:

$$n = \frac{16\,L^2}{d^2} \qquad (3)$$

where

L = length of chromatogram
d = distance of peak width measured along the baseline between the tangents to the inflection points of the distribution curve.

The Van Deemter criterion was fulfilled in all cases for the sample volume of one cubic centimeter of gas at atmospheric pressure and room temperature.

(d) Correction for dead volume of detector. The dead volume of the detector cell affects both the retention volume and peak width. Johnson and Stross[6] have developed a theory for thermal conductivity detector corrections and have utilized the theory to correlate experimental data reflecting detector dead volume. Their correlation was used to calculate the dead volume of the detector.

Vapor-Liquid Equilibrium Ratios (K-Values). An alternative definition of the partition coefficient is:

$$H = \frac{x}{y}\frac{M_s}{M_m} \qquad (4)$$

where

x = mole fraction of solute in the liquid
y = mole fraction of solute in the gas
M_s = moles of stationary phase per cc of liquid
M_m = moles of mobile phase per cc of gas

since $\frac{x}{y} = \frac{1}{K}$, in particular at infinite dilution

$$H^o = \frac{1}{K}\frac{M_s}{M_m} \qquad (5)$$

Assuming ideal gas behavior

$$M_m = \frac{\pi}{RT} \qquad (6)$$

and the moles of stationary phase

$$M_s = \frac{s}{MW_s} \qquad (7)$$

where s = density of stationary phase
MW_s = molecular weight of stationary phase

Substitution yields

$$H^o = \frac{1}{K}\frac{s}{\pi}\frac{RT}{MW_s} \qquad (8)$$

Eliminating H^o using equation 1 and rearranging

$$K = \frac{s}{\pi}\frac{RT}{(V_R^o - V_m)MW_s}\frac{V_s}{} = \frac{RT}{\pi (V_R^o - V_m)MW_s}\frac{W_s}{} \qquad (9)$$

since $sV_s = W_s$, the mass of the stationary liquid.

The application of Equation 9 to give K-values requires a knowledge of the temperature, weight of liquid in the column, the corrected retention volume of the solute, the void volume of the column, and the molecular weight of the liquid, the volume being taken at column conditions.

Activity Coefficients. For systems exhibiting non-ideal behavior in the liquid phase, the Raoult-Dalton relationship is modified to give

$$\pi y = \gamma P^o x \qquad (10)$$

where

where π = total pressure
y = mole fraction of the solute in the gas
x = mole fraction of the same solute in the liquid
P^o = vapor pressure of the solute at the equilibrium temperature.

Eliminating y in Equation 4 gives

$$H^o = \frac{\pi}{M_s}\frac{\gamma P^o}{M_m} \qquad (11)$$

Eliminating M_m using Equation 6 and solving for γ gives the relation derived by Porter *et al*[16] for the activity coefficient at near infinite dilution:

$$\gamma^o = \frac{M_s RT}{H^o P^o} \qquad (12)$$

Using the definition of the corrected retention volume as given in Equation 1, the activity coefficient can finally be written in terms of the corrected retention volume:

$$\gamma^o = \frac{M_s RTV_s}{(V_R^o - V_m)P^o} \qquad (13)$$

By using a small sample size (1 cc gas at 760 mm.Hg.), the activity coefficient was made to approach the activity coefficient at infinite dilution, γ^o.

The Relative Volatility. The volatility of component 1 relative to

TABLE 1—Column Characteristics*

	Length (cu)	Ratio Support/ Solvent	Column Volume (cc)	Support Volume (cc)	Liquid Volume (cc)	"Free" Gas Volume (cc)	Mass Stationary Phase (gr)	Free Gas Cross Section (cm^2)	Free Liquid Cross Section (cm^2)	Mesh Size
n-Dodecane—Firebrick C-3										
I	152.7	100:18.28	71.82	15.29	7.98	41.54	6.0098	.318	.0523	30—50
Furfural—Firebrick C-3										
II	122.2	100:26.9	57.45	12.78	6.37	38.30	7.39	.313	.0520	30—50
III	152.7	100:26.9	71.81	16.13	8.05	47.64	9.33	.312	.0528	30—50
IV	152.7	100:26.9	78.82	16.33	8.14	47.35	9.45	.310	.0533	30—50

* All were built with copper tubing ⅜" OD and 0.305" ID.

component 2, a_{12}, is defined as:

$$a_{12} = \frac{y_1/x_1}{y_2/x_2} \qquad (14)$$

The relative volatility is a measure of the ease of separation of components 1 and 2. The relative volatilities measured chomatographically give an indication of the ease of separation which can be achieved by extractive distillation under low solute and high solvent concentrations in the liquid phase.

Differential Heat of Solution. The differential heat of solution, ΔH_{sln}, may be calculated from the following familiar relationship (4):

$$\frac{d(\log \gamma_1)}{d\left(\frac{1}{T}\right)} = \frac{\Delta H_{sln}}{2.303\,RT} \qquad (15)$$

where

ΔH_{sln} = differential heat of solution, Btu/lb.mole.
T = absolute temperature, °R
R = gas constant, 1.987 Btu/lb. mole, °R.

A plot of log γ_1 versus $\frac{1}{T}$ gives ΔH_{sln} as the slope. Since the concentrations of the solute in the solvent phase is small, ΔH_{sln} approaches the ΔH_{sln} at infinite dilutions. At infinite dilutions log γ_1 is numerically equal to the Margules binary constant, A.

EXPERIMENTAL APPARATUS

The GLPC apparatus used in the investigation is, in principle, similar to the one described by Price and Kobayashi.[18] However, the following special features were incorporated in the apparatus in order to reduce the magnitude of the corrections outlined in the previous sections. The sample system was a capillary tube of 1 ml volume connected to two 3-way glass stopcocks. Through the use of capillary copper tubing, dead volume was reduced to 3 ml before the packed section of the column and 2.1 ml after it.

The gas volume of the detector cell was 4.655 ml with 8 filaments located "on stream" to give a low time constant. The columns and detector were immersed in a constant temperature liquid bath whose temperature was regulated to 0.05° C.

The column characteristics are listed in Table 1. In the preparation of the columns, to insure an even distribution of the stationary liquid phase over the surface of the solid, the stationary liquids, n-dodecane in one case and furfural in the other were dissolved in 8 to 10 times their volume of isopentane and ethyl ether, respectively. The solvents were subsequently removed by evaporation to constant weight.

EXPERIMENTAL RESULTS

The retention volumes were calculated as the product of the flow rate times the period elapsed from the injection point to the maximum of the distribution curve, which corresponds to the maximum concentration of the solute in the effluent. These values were corrected in accordance with the relations discussed above to give the corrected retention volumes.

Vapor-Liquid Equilibrium Ratios for n-Butane. The K-values for n-butane in n-dodecane were calculated from the corrected retention volumes through the application of Equation 9. The values are reported in Table 2. Runs were made at various temperatures, from 0° to 30° C., and pressures from 18 to 40 psia using helium as the elution gas.

The experimental K-values and those reported in the Natural Gasoline Association of America K-Value Charts[13] for the same conditions of pressure and temperature and a 20,000 psia convergence pressure are given. Such a high convergence pressure was chosen because the gas phase was predominantly helium and the liquid phase predominantly n-dodecane.

Figure 1 gives the K-values for *n*-butane in *n*-dodecane as a function of pressure for various temperatures.

Similar runs were made in which methane, ethane, ethylene, and propane were eluted through the column with helium using n-dodecane as the fixed liquid phase. The retention volumes for these gases in the neighborhood of 0° C. were not high enough to yield accurate K-values.

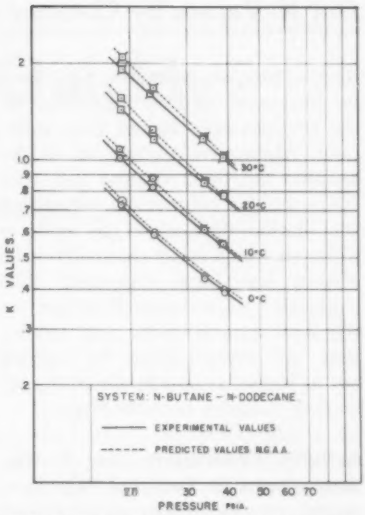

FIGURE 1—Comparison of chromatographic K values with those from static equilibrium.

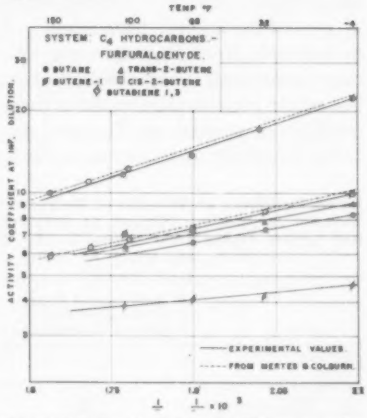

FIGURE 2—Activity coefficients at infinite dilution for C_4-hydrocarbons in furfuraldehyde.

TABLE 2—Vapor-Liquid Equilibria (K-Values) for the System *n*-Butane *n*-Dodecane

Temperature (°C)	Mean Pressure (psia)	Flow Rate (cc/min)	Corrected Retention Volume (cc)	Chromatographic K-Values	K-Values NGAA	Percent Deviation
0	18.88	49	887	0.735	0.76	—3.29
0	24.00	49	870	0.589	0.605	—2.64
0	33.99	49	831	0.437	0.43	+1.63
0	38.95	48	783	0.406	0.39	+4.10
10	18.70	50	682	1.017	1.09	+7.34
10	23.70	50	673	0.814	0.88	—7.50
10	34.11	50	624	0.614	0.635	—3.31
10	38.88	50	609	0.553	0.565	—2.12
20	18.70	50	520	1.415	1.52	—6.91
20	23.60	51	500	1.17	1.22	—4.10
20	34.11	49	497	0.850	0.875	—2.85
20	39.28	49	459	0.774	0.78	— .77
30	18.85	50	408	1.90	1.97	—3.55
30	23.67	50	388	1.605	1.60	+3.12
30	34.04	50	371	1.17	1.15	+1.74
30	39.00	50	376	1.01	1.01	0.0

The techniques presented here must be improved and/or modified for the hydrocarbons lighter than n-butane. Alternative techniques to determine the dead volume and void space in the column by measuring the elution time of a gas such as nitrogen which is not retained on the solvent has been suggested. The evaluation of accurate K-values for the light hydrocarbons may require that the investigations be carried out at higher pressures where the retention volumes become larger.

Activity Coefficients for C_4-Hydrocarbons in Furfural. The corrected retention volumes obtained from the chromatogram were used to calculate the activity coefficients of *n*-butane, butene-1, *trans*-butene-2, *cis*-butene-2, and butadiene-1, 3 in furfural. Since the activity coefficient represents values obtained at low solute concentrations, the activity coefficients plotted on Figure 2 are termed activity coefficients at "infinite dilutions." Also shown are the activity coefficients for n-butane and butene-1 at infinite dilutions as determined from the static equilibrium tests of Mertes and Colburn.[12]

Differential Heats of Solution of C_4-Hydrocarbons in Furfural. The variation of the activity coefficient with temperature was obtained from Figure 2 and used in Equation 15 to obtain the differential heats of solutions of the C_4-hydrocarbons in furfural. The values are listed in Table 3. The differential heats of solution obtained from GLPC for n-butane from —20° to 40° C. was 3900 Btu/lb. mole., while Mertes and Colburn[12] report a value of 3180 Btu/lb. mole. from 38° C. to 93° C. For butene-1 in furfural, the GLPC value was 2565 as compared to 2400 Btu/lb. mole. from Mertes and Colburn.

Relative Volatilities of C_4-Hydrocarbons in Furfural. The relative volatilities, defined in terms of activity coefficients by Equation 14, which were obtained from GLPC measurements, are given in Table 4, together with one set based on static equilibrium values.[2]

TABLE 3—Heats of Solution of C_4-Hydrocarbons at Infinite Dilution in Furfural and Latent Heats Over Range —20° C to 40° C

	Differential Heats of Solution Btu/lb. mole of C_4 Dissolved
n-Butane	3140
Butene-1	2015
Trans-Butene-2	1752
Cis-Butene-2	1558
Butadiene-1, 3	900

	Latent Heats of Vaporization			Btu/lb. mole*
n-Butane	10030	9560	9140	8670
Butene-1	9750	9360	8910	8500
Trans-Butene-2	10280	9845	9400	8920
Cis-Butene-2	10600	10090	9660	9130
Butadiene-1, 3	9950	9520	9090	8630

* When values were not available at the temperature indicated, they were calculated from the empirical equation of Watson[22].

TABLE 4—Relative Volatilities of Individual C_4-Hydrocarbons in Solvent Furfural at Infinite Dilution (pressure 20-40 psia)

Component	TEMPERATURE —20° C	0° C	20° C	40° C
n-Butane	4.070	3.435	3.015	2.402
Butene-1	2.330	2.245	1.930	1.772
Trans-Butene-2	1.554	1.570	1.450	1.341
Cis-Butene-2	1.248	1.256	1.190	1.162
Butadiene-1, 3	1.000	1.000	1.000	1.000

Reported Values of Volatilities of C_4-Hydrocarbons in Furfural + 4% Water

T = 54° C	P = 65 psia
n-Butane	2.02
Butene-1	1.718
Trans-Butene-2	1.19
Cis-Butene-2	1.065
Butadiene-1, 3	1.00

ACKNOWLEDGMENTS

The authors acknowledge the earlier efforts of Dr. A. Roy Price and Enrique Rangel in the construction of GLPC apparatus and the analyses of their results. The hydrocarbons were contributed by the Phillips Petroleum Company. The authors express their appreciation to Howard A. Thompson and the Development Office for aid in the preparation of the manuscript.

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Mellado

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Estimate Inert Gas Plants Quickly

Use these charts for rapidly estimating the direct installed costs for inert gas plants up to 100,000 scfh.

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The Chemstrand Corp., Pensacola, Fla.

THE CHEMICAL PROCESSING PLANT requires a relatively large amount of inert gas compared to other types of industries. The inert gas plant is considered an integral part of the plant utility system as it is one of the basic services required for protecting refinery or chemical processing systems. Inert gas is also used directly to prevent air from contacting reactants or products where oxidation is undesirable, conveying chemicals or general blanketing and purging of vessels.

Equipment selection for the inert gas plant requires a comprehensive study of requirements of the processing plant, the equipment for the inert gas plant, and general operating conditions. The size of the inert gas plant, type of fuel and the available space and arrangement influence the selection of equipment.

The inert gas load—normal, peak, and minimum loads, and the continuity of operation—must be determined in order to select the inert gas plant equipment which will provide the lowest inert gas cost consistent with reliable plant operation. This article presents carefully prepared data for estimating the cost of these inert gas plants in sizes of 1,000 to 100,000 standard cubic feet per hour (scfh) of inert gas capacity.

Generator. A schematic flowsheet for a typical inert gas plant is shown in Figure 1. The inert gas generator consists of a fuel pressure regulator, air filter, adjustable carburetor, motor driven turbo-compressor, burner, refractory lined combustion chamber, shell and tube gas cooler with water separator and trap, relief valve, and panel mounted safety controls and suitable instrumentation. The inert gas generators are usually the "package type" mounted on a single skid for sizes up to 15,000 scfh. Where larger size units are employed, the major items of equipment are mounted on individual skids. The inter-connecting piping required for each unit is furnished as a part of the "package." The electrical equipment furnished will be NEMA-4 construction unless otherwise specified. The purchased cost for the complete inert gas generating unit along with the equipment erection time in man hours is shown in Figure 2.

The carbon dioxide removal unit consists of a carbon steel packed absorber column and stripper tower, shell and tube heat exchangers of cast iron and steel construction, solution pumps of all iron construction, welded steel reboiler with removable bundle, and sufficient panel mounted controls and instruments to provide a functional unit. The CO_2 removal units are also the "package type" mounted on skids. As with the gas generating unit, all inter-connecting piping is furnished. The electrical equipment furnished is suitable for outdoor installation. The purchase cost of CO_2 removal units in sizes 1,000 to 100,000 scfh of gas-feed and the required labor for installation in man hours are shown in Figure 3.

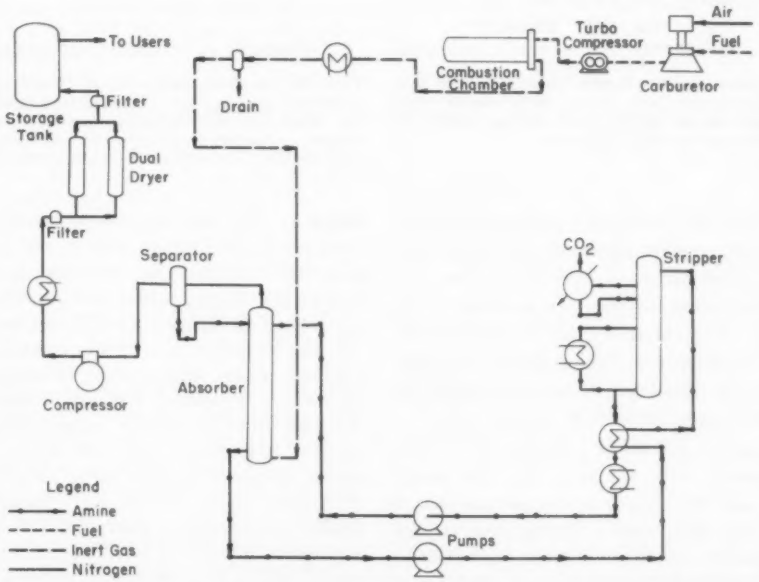

FIGURE 1—Inert gas plant with CO_2 removal scheme, dryers, compressors and pressure storage.

Compression. The inert gas compression system consists of a motor driven reciprocating compressor, shell

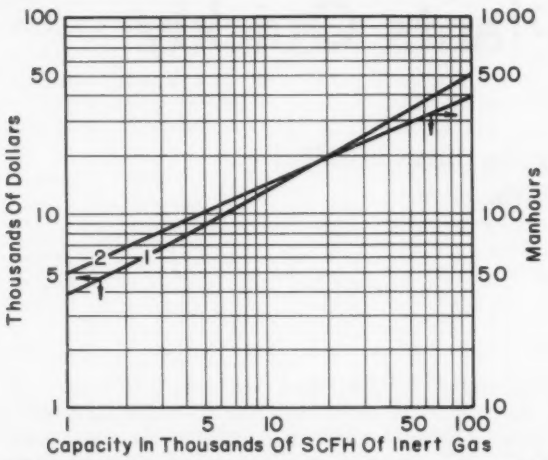

FIGURE 2—Inert Gas Generator equipment and erection costs. 1—Purchased equipment (FOB) including gas pressure regulator, carburetor, turbo-compressor, burners, combustion chamber, heat exchanger, with separator and trap, and relief valve. 2—Equipment erection manhours cover unloading, storing, hauling, rigging, setting and testing.

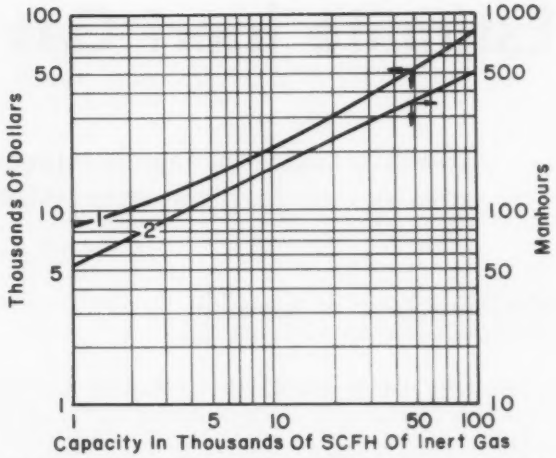

FIGURE 3—Carbon dioxide removal units include costs (FOB) for 1—packed absorber tower, an amine reboiler and stripper tower, solution pumps, heat exchangers and appropriate instrumentation as well as all manhours for erection, handling and testing.

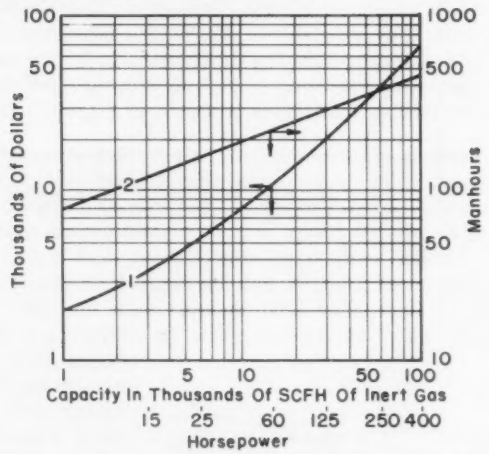

FIGURE 4—Compressors and auxiliaries (based on 100 psig discharge) include 1—motor, belt drive, after cooler with separator and trap, and viscous impingement suction filter with all 2—erection, handling and testing manhours.

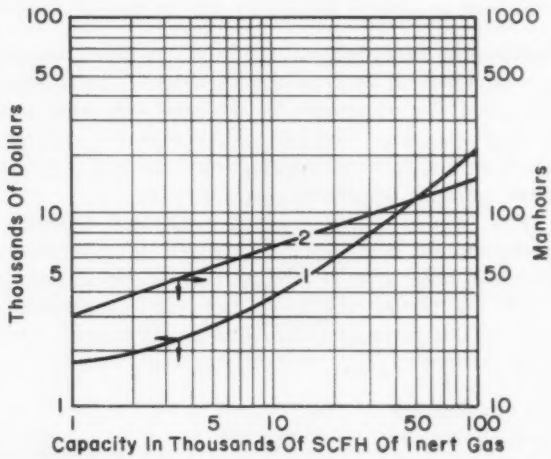

FIGURE 5—Adsorption dryers (based on 100 psig and 90° F saturated gas) include 1—purchased equipment (FOB) including dual towers, desiccant material, electrical reactivation heater, wiring and controls, interconnecting valves and piping, and prefilter as well as 2—equipment erection manhours.

and tube type aftercooler, moisture separator and trap. The compressor is the conventional heavy duty, horizontal type with water jacketed cylinders. The unit furnished is a double acting, single stage machine up to 15,000 scfh capacity. For capacities above 15,000 scfh, a double stage unit is employed. Both types of compressors are driven through a multiple V-belt connection by an open type squirrel cage, induction motor.

The required capacity control is provided by a constant compressor speed with unloaders for the single stage compressors, and the clearance control method is used on the two stage compressors. Lubrication is provided by a combination splash and force feed system. The total purchase cost and erection labor in man hours for the compression system can be estimated using the data shown in Figure 4.

Dryers. The inert gas drying system consists of a desiccant filled prefilter, afterfilter and dual desiccant filled absorber towers. The prefilter afterfilter and drying towers are designed and fabricated in accordance with the ASME Code for Unfired Pressure Vessels. The dryers are also furnished as a "package unit" mounted on skids. Pressure gages, temperature indicators and safety relief valves are provided for each tower. Reactivation of the desiccant is usually accomplished with embedded electric heaters for dryer sizes up to 35,000 scfh and external electrical heaters with blowers are provided for unit sizes above 35,000 scfh. Steam reactivation can readily be employed and the cost for either system is approximately the same. The required inter-connecting piping and a local mounted control panel are also provided. A semi-automatic operation is used for reactivation of the desiccant. After the desiccant is saturated

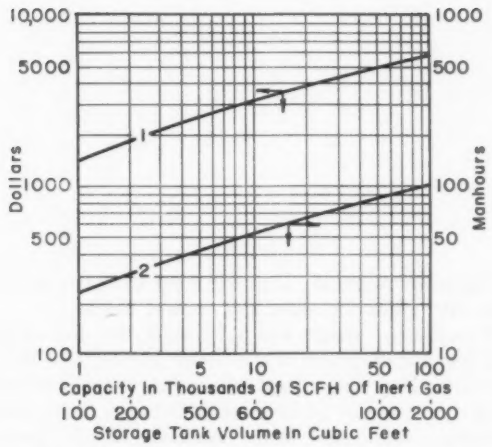

FIGURE 6—Storage tank purchased cost (FOB) includes 1—skirt support, 20-inch manhole, relief valve, pressure gage, and drain valves based on ASME Code and dished heads. Piping is included on Figure 7. Equipment erection 2—includes all erection and testing manhours for outside tank location. Concrete pad included on Figure 7.

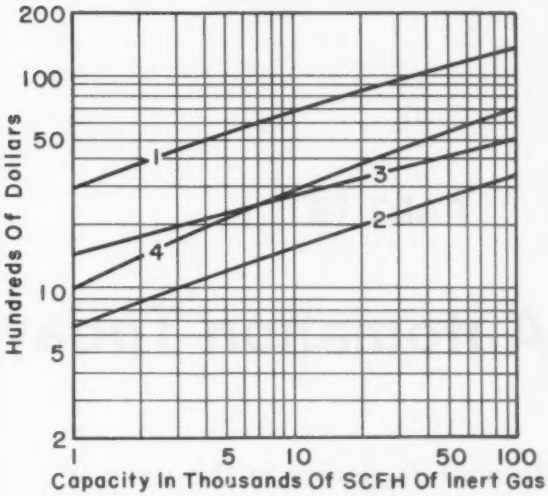

FIGURE 7—Miscellaneous costs are 1—Piping labor and materials, 2—Concrete labor and materials, 3—Building (metal construction) labor and materials, and 4—Electrical labor and materials which includes motor control center, 100 feet of conduit and wire and lighting.

(normally an 8-hour period) in one tower, the gas is manual shifted to the alternate tower. The remaining part of drying and reactivation cycle is automatic. The total purchased cost of these "packaged" drying systems and the required installation labor is shown in Figure 5. If fully automatic reactivation is used, these costs must be increased 25 percent for unit sizes up to 35,000 scfh and 15 percent for all other sizes.

Storage Tank. The final inert gas product is usually held in a storage tank maintained at approximately 100 psig to provide surge capacity for the system. The storage tank is fabricated from carbon steel plate with dished heads in accordance with the ASME Code of Unfired Pressure Vessels and supported from a skirt and base ring. The cost of typical surge tanks is shown in Figure 6. In the absence of specific surge capacities as dictated by process requirements, suggested surge volume may also be obtained from Figure 6.

Piping and Building. The piping required to connect the various "package" items comprising a fully integrated inert gas plant is fabricated from carbon steel employing both screwed and welded fittings. A separate prefabricated metal building is commonly used to house the equipment. The total cost for piping, concrete foundations, metal building and the associated electrical facilities are plotted versus inert gas plant capacity in Figure 7. No allowance has been included for piping and equipment insulation.

Example. The following example will illustrate how the cost data presented is used for determining the total direct installed cost for an inert gas plant.

Estimate the total direct installed cost for an inert gas plant with a capacity of 44,000 scfh of CO_2 free inert gas. To produce this capacity, 50,000 scfh of generator capacity is required. Since at times it is desirable to by-pass the CO_2 removal system, the compressors, dryer and storage system will be sized for the full generator capacity.

Inert Gas Generator

From Figure 2:	
Equipment Cost	$35,000
Erection Labor: 290 MH @ $3.50/MH	1,015
	$36,015

Carbon Dioxide Removal Unit

From Figure 3:	
Equipment Cost	$52,000
Erection Labor: 365 MH @ $3.50/MH	1,278
	$53,278

Compressor and Auxiliaries

From Figure 4:	
Equipment Cost	$32,000
Erection Labor: 340 MH @ $3.50/MH	1,190
	$33,190

Adsorption Dryer:

From Figure 5:	
Equipment Cost	$12,000
Erection Labor: 120 MH @ $3.50/MH	420
	$12,420

Storage Tank

From Figure 6:	
Equipment Cost	$4,900
Erection Labor: 85 MH @ $3.50/MH	297
	$7,197

Miscellaneous Costs

From Figure 7:	
Piping (Labor & Material)	$11,500
Concrete (Labor & Material)	2,750
Building (Labor & Material)	4,100
Electrical (Labor & Material)	5,400
	$23,750

Total Plant Cost	**$163,850**
Total Cost/scfh	**$ 3.277**

ACKNOWLEDGMENT

The authors are grateful to Andress Mouat and Associates, Inc., who supplied equipment cost data on the C. M. Kemp Manufacturing Company inert gas equipment.

PART 18

Automation Today

Previous discussions in this series concerned open loop systems and sine wave frequency responses. Now the authors tackle closed loop systems and introduce the concept of complex frequencies

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Monsanto Chemical Company, St. Louis, Mo.

IN THE PREVIOUS articles of this series we have discussed in considerable detail both the Bode and the Nyquist diagrams concentrating mainly on a study of the open loop transfer function and the sine wave frequency response of the system being studied. The reader will now be introduced to a more complete study of the closed loop transfer functions of controlled chemical systems and be shown the relation of frequency response to transient response. This will help to better acquaint him with all of the aspects of control theory.

The present article will summarize the uses of Bode and Nyquist diagrams of the closed loop system. We will also introduce the concept of the "complex frequency." This concept must be understood before a third plotting technique, the "root locus" method, can be properly described.

THE OPEN LOOP BODE DIAGRAM

To assure continuity, we will redevelop the open loop functions of an example system before the corresponding closed loop relations are discussed. Let us consider the process control system illustrated in Figure 117. This control complex is a slightly simplified version of the example used previously for the development of the Bode and Nyquist techniques.

The changes and simplifications have been made to make the problem more adaptable to the use of both the root locus and the closed loop system studies. The interconnecting pipe has been assumed to be short, thereby eliminating the true time delay previously considered. The two kettles are of different sizes to make the example more descriptive of control theory applications. Also, only proportional control will be considered at present.

The usual simplifying assumptions used with the example gives the transfer function, $\frac{K}{(T_1p+1)(T_2p+1)}$. Let us also assume that $T_1 = 1$ time unit and $T_2 = 0.5$ time unit. We may then draw the Bode diagram of the resulting system by using the asymptote techniques which

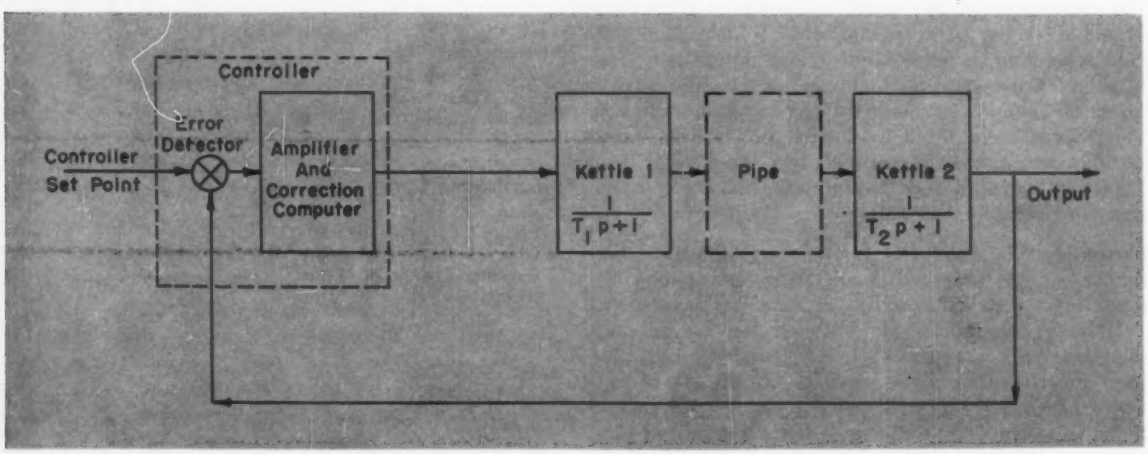


FIGURE 117—This control system is a slightly simplified version of the example used previously.

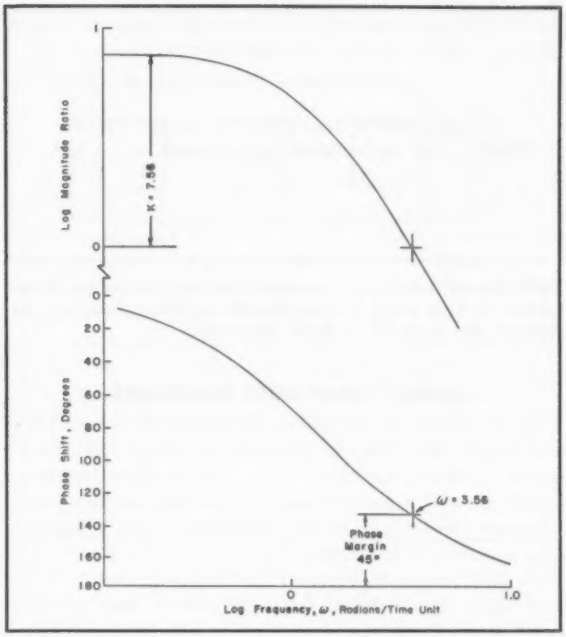


FIGURE 118—The Bode diagram for the open loop control system shows a gain of 7.56 can be used for a phase margin of 45°.

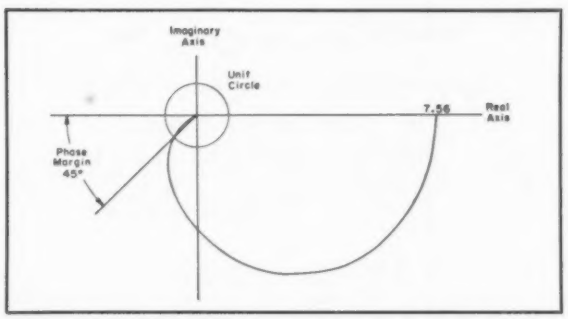


FIGURE 119—The Nyquist diagram for the open loop control system can also be used to show the gain and phase margin of the system.

we have learned from previous articles of this series. Such a procedure yields Figure 118. From this Bode diagram we find that the system needs a proportional constant, K, or gain of 7.56 for a phase margin, ψ, of 45°.

OPEN LOOP NYQUIST DIAGRAMS

If we take the transfer function $\frac{K}{(T_1p+1)(T_2p+1)}$ and let $p = j\omega$, we can make the following algebraic manipulations:

$$\frac{\Delta F}{E} = \frac{K}{j\omega(T_1+T_2)+(1-T_1T_2\omega^2)} =$$

$$\frac{K}{j\omega(T_1+T_2)+(1-T_1T_2\omega^2)} \frac{j\omega(T_1+T_2)-(1-T_1T_2\omega^2)}{j\omega(T_1+T_2)-(1-T_1T_2\omega^2)}$$

$$= \frac{+j\omega(T_1+T_2)K-(1-T_1T_2\omega^2)K}{-\omega^2(T_1+T_2)^2-(1-T_1T_2\omega^2)^2} \qquad (1)$$

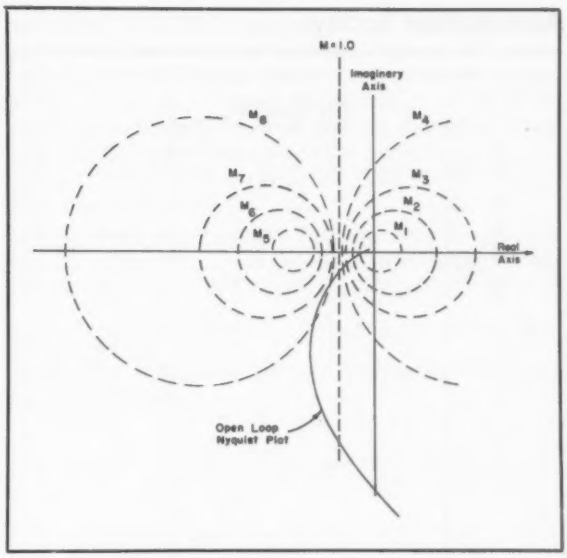


FIGURE 120—The circles shown here represent loci of constant closed loop magnitude ratios for comparison with the open loop Nyquist diagram of the control system. In this plot: $M_1 < M_2 < M_3 < M_4 < 1.0 < M_5 < M_6 < M_7 < M_8$.

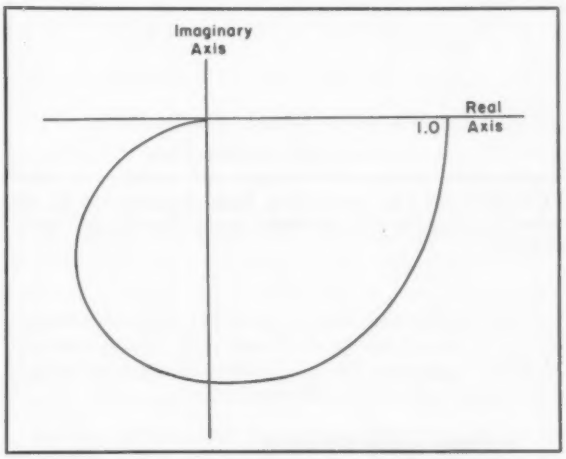


FIGURE 121—The closed loop Nyquist diagram can be plotted from the information given in Figure 120.

Rearranging the resulting expression and separating it into both *real* and *imaginary* parts, we obtain our final frequency response function:

$$\frac{\Delta F}{E} = \frac{(1-T_1T_2\omega^2)K}{\omega^2(T_1+T_2)^2+(1-T_1T_2\omega^2)^2} - j$$

$$\frac{\omega(T_1+T_2)K}{\omega^2(T_1+T_2)^2+(1-T_1T_2\omega^2)^2} \qquad (2)$$

This algebraic function may be plotted in the complex plane to yield the Nyquist diagram shown in Figure 119.

The Nyquist diagram may also be plotted directly from the Bode plot by replotting the magnitude and phase curves onto the complex plane as we have described before. On a Nyquist diagram for our example

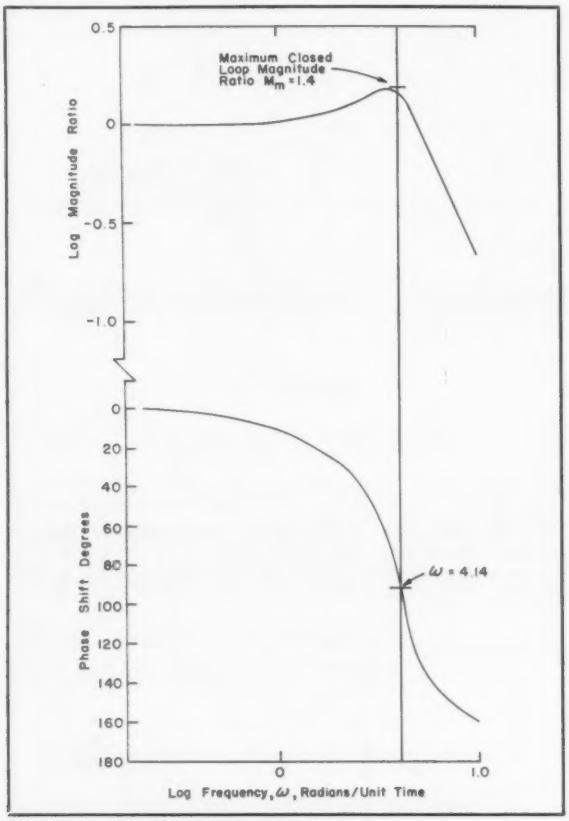


FIGURE 122—The closed loop Bode diagram can be obtained by using the data presented on the closed loop Nyquist diagram.

system, we can also plot various constant M (magnitude) circles as shown in Figure 120. These constant M circles represent loci of constant *closed loop* magnitude ratios, and will be discussed next.

CLOSED LOOP NYQUIST DIAGRAMS

From the Nyquist plot shown in Figure 120 we can develop the corresponding closed loop Nyquist diagram. To obtain this plot, we take the value of the constant magnitude (M) circle which becomes just tangent to the Nyquist curve at a particular point and plot that value of M and associated constant phase curve on a new Nyquist diagram. When this is done for various M circles and constant phase lines, it yields the closed loop Nyquist diagram for this system which is shown in Figure 121. For simplicity, the constant phase curves are not shown but they are necessary to construct the closed loop Nyquist diagram. (See Figures 103 and 105, Part 16, to have an example of these.)

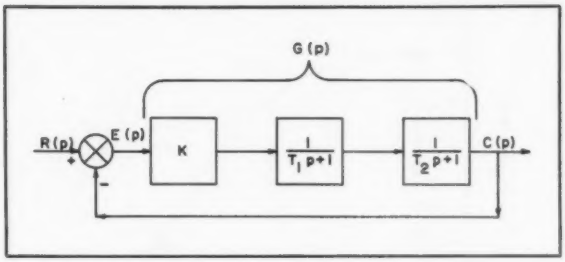


FIGURE 123—Even a very simplified representation of the control system gives a complicated algebraic equation for plotting the Nyquist or Bode diagrams.

CLOSED LOOP BODE DIAGRAMS

In a reversal of our previous procedure, we can use the closed loop Nyquist diagram to obtain the corresponding closed loop Bode plot. This is done by transferring points for each frequency from the complex plane (Nyquist) to the plot of M (magnitude) and ψ (phase) as a function of frequency. The result is the closed loop Bode plot shown in Figure 122. This same figure could also have been derived from the closed loop transfer function of the system.

If we refer to the block diagram of the system (Figure 123) we can derive this closed loop transfer function as follows:

$$\text{If } G(p) = \frac{K}{(T_1 p + 1)(T_2 p + 1)}, \text{ then}$$

$$C(p) = E(p)\,G(p) = G(p)\,[R(p) - C(p)]$$

$$C(p) + C(p)\,G(p) = G(p)\,R(p)$$

$$\frac{C(p)}{R} = \frac{G(p)}{1 + G(p)} = \frac{K/(T_1 p + 1)(T_2 p + 1)}{1 + \dfrac{K}{(T_1 p + 1)(T_2 p + 1)}} =$$

$$\frac{K}{K + (T_1 p + 1)(T_2 p + 1)} \qquad (3)$$

If we let $p = j\omega$ we can also solve this function for its real or imaginary parts so that we could plot the

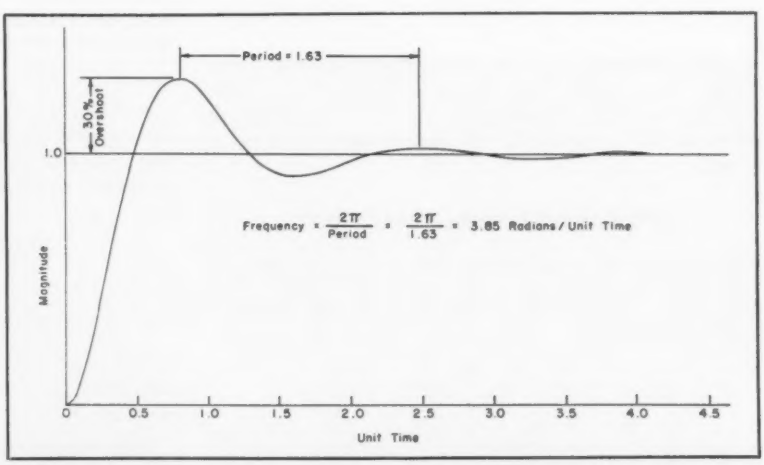


FIGURE 24—A unit step input to the control system will give a transient response represented by a damped oscillation. The frequency is equal to 2π/Period, that is, 3.85 radians per unit time.

Nyquist or Bode diagrams directly. However, this latter is not a very common practice because of the complicated algebra involved.

RELATION OF FREQUENCY RESPONSE TO TRANSIENT RESPONSE

Note that for the open loop Bode diagram (Figure 118) and for the open loop Nyquist (Figure 119) the phase margin, at M = 1, is 45°. This had previously been specified as a general rule to follow from control theory in order to yield a good transient response. Let us now show why this is true.

It can be seen from the closed loop Bode plot (Figure 122) or the closed loop Nyquist (Figure 121) that the maximum value of M is 1.4 (maximum *closed loop* magnitude ratio) and that it occurs at a break frequency $\omega_n = 4.14$ (notice that this is the point of 90° phase shift rather than the maximum of the peak). In order to find whether or not the general rule of 45° phase margin is a good criteria, a plot of the transient response of the system to a step input is now required. From either the open loop Bode or Nyquist diagrams of this second order system, we see that the frequency at M = 1 and $\psi = 45°$ is 3.56 radians/time unit. (This is *open loop* magnitude ratio.)

The closed loop transfer function of our system is that of a typical second order system. This transfer function can be expressed in a generalized form as $\frac{1}{T^2p^2 + 2\delta Tp + 1}$ where $T = \frac{1}{\omega_n}$ and δ is the damping factor. The closed loop transfer function of our example is, therefore,

$$\frac{K}{K + (T_1p + 1)(T_2p + 1)} = \frac{K}{T_1T_2p^2 + (T_1 + T_2)p + (1 + K)}$$

$$= \frac{K}{1 + K} \cdot \frac{1}{\frac{T_1T_2}{1 + K}p^2 + \frac{T_1 + T_2}{1 + K}p + 1} \qquad (4)$$

In relation to the general second order system, we see that $T_1T_2/(1 + K) = T^2$; $(T_1 + T_2)/(1 + K) = 2\delta T$, and $K/(1 + K)$ is a new gain factor. If we now let $T_1 = 1.0$ time unit, $T_2 = 0.5$ time unit, and $K = 7.56$, we find that $T = .242$ time unit or $\frac{1}{T} = \omega_n = 4.14$ radians/time unit and $\delta = .36$, δ is the so-called damping factor of the system. A plot of the transient response to a unit step input of this system (also our example) is shown in Figure 124.

The reader will notice that ω_n is the *undamped natural* frequency of oscillation. ω_a, the frequency at which system oscillation occurs is *less* than ω_n and is the *actual* frequency at which the system oscillates. The transient response is exactly as we expected. The overshoot is 30 percent and the actual frequency of oscillation ω_a is 3.85 radians/time unit.

As can be seen, this yields approximately 1½ cycles of oscillation before reducing the error from steady state to 5 percent or less and an overshoot of 30 percent which is considered a good transient response for a closed loop system.

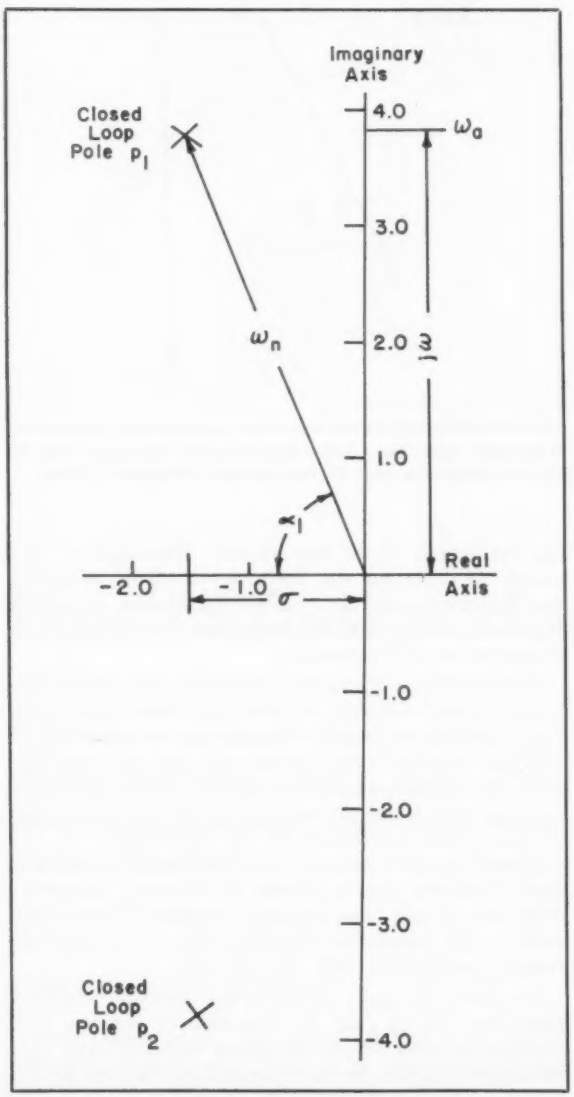


FIGURE 125—This is how the closed loop poles of the example process are plotted in the complex plane.

COMPLEX FREQUENCY

In our earlier work we have defined p = d/dt. For frequency response studies we then allowed p to equal jω. However, in letting p = jω we actually imposed a restriction on the use of the symbol p by confining it to sinusoidal oscillations. Actually, p itself can be considered to be a complex number, that is, contain both real and imaginary parts. A plot of this complex number gives us what is called the p plane. P itself is then usually called the "complex frequency," a term derived from the electrical engineering field.

From a study of the Laplace Transform it may be shown that p can be considered as the specific complex number ($p = \sigma + j\omega$) where σ equals the real part of the function and jω equals the imaginary part. The

mathematical proof of this will not be presented here. It may be found in any standard servomechanism text. Previously we have been considering p to have values only along the imaginary axis of the complex frequency plane (i.e., $p = j\omega$) instead of anywhere in the p plane ($p = \sigma + j\omega$).

If we take the closed loop transfer function of our system prior to making any mathematical manipulations on it and if we solve for the roots of p, we will find them to be complex as described above. These roots are called the poles of the transfer function. If we solve the denominator for its roots (poles) (i.e., $\frac{T_1T_2p^2}{1+K} + \frac{T_1+T_2}{1+K}$ $p + 1 = 0$) by the quadratic formula and let $T_1 = 1.0$ time unit; $T_2 = 0.5$ time unit, and $K = 7.56$, we obtain $p_1 = -1.5 + j\,3.85$; $p_2 = -1.5 - j\,3.85$. A plot of these roots in the complex frequency plane is shown in Figure 125. $j\omega$ and σ are shown in their proper relation on this diagram.

We can now relate the constants of the control system to the complex frequency diagram. Notice that the imaginary part of p (i.e., $j\omega$) is the actual frequency of oscillation (ω_a) of the system. The magnitude of the vector from the origin to the pole p_1 is the value of the *natural* frequency of oscillation ω_n (i.e., the frequency at which the system will oscillate if *no* damping is present). It is important to notice the application of damping decreases the true (or actual) frequency of oscillation.

The damping factor controls the actual frequency of oscillation. The damping factor is in turn associated with the angle α_1. In fact, cosine $\alpha_1 = \delta$. We can see from the above statement that if δ equals zero, then α_1 equals 90°. The poles (p_1 and p_2) will appear on the imaginary axis. Also, now $\omega_n = \omega_a$ and the system is in sustained oscillation at the frequency of ω_n which is also the actual frequency (ω_a) of oscillation. It is also apparent that if δ becomes negative (i.e., α_1 is greater than 90°) the poles enter the right half plane. We know this condition is one of instability. Thus δ must always be positive and less than unity for acceptable transient behavior.

RELATIONS OF CLOSED LOOP PLOTS TO THE COMPLEX FREQUENCY PLANE

Notice the closed loop Bode and Nyquist diagrams also may be plotted from the complex frequency plane plot. Referring to Figure 126, select a frequency ω_1 on the imaginary axis. Draw the vectors from the poles p_1 and p_2 to the point ω_1. Let us call these vectors G_1 and G_2 consecutively. Now we see that the total transfer function $G(p) = \frac{K}{G_1G_2} = \frac{K}{(p+p_1)(p+p_2)}$ and let $p = j\omega$.

$G(p) = G(j\omega) = \frac{K}{(j\omega+p_1)(j\omega+p_2)}$ which is the actual complex number required to plot the closed loop Nyquist and Bode diagrams. It follows that $|G| = \frac{K}{|G_1||G_2|}$ and the value of $|G|$ can be found by graphically multiplying the length of the two vectors. The angle of G is simply $(\theta - \beta)$ for the frequency ω_1. This procedure can be carried out for various frequencies along the imaginary axis to yield the closed loop Nyquist and Bode diagrams for all frequencies.

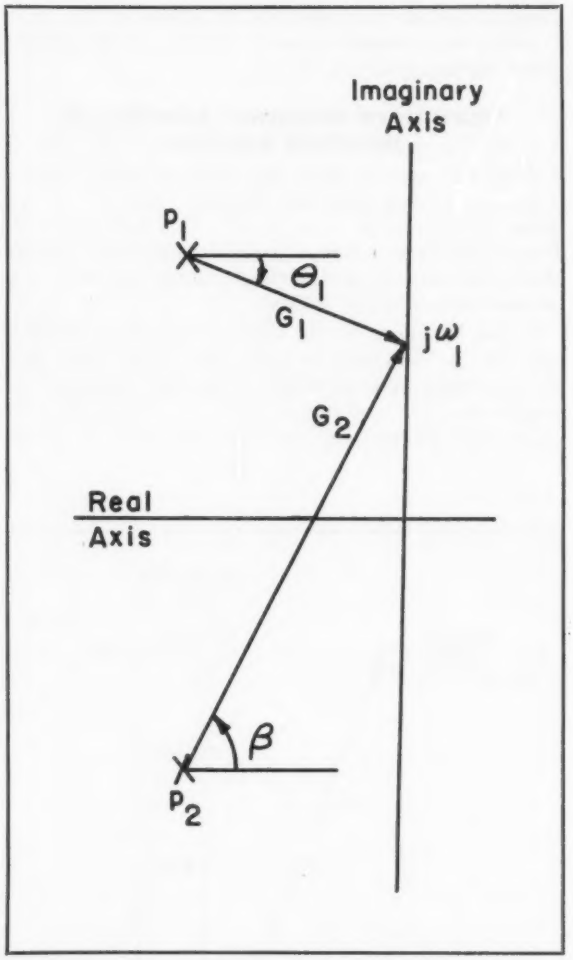


FIGURE 126—The Bode and Nyquist diagrams can be derived from the plot of the complex frequency plane.

The location of these poles plotted in the complex frequency plane will shift for each and every value of K (gain), since we would obtain a new set of roots for each K. The way in which these poles move in the plane, as K varies, gives us an understanding of *both* frequency response and transient response of the system on one diagram. The correlation of this information on one diagram is possible because the closed loop Nyquist and Bode diagrams may be drawn by following frequency along the $j\omega$ axis. The transient response is known because of the knowledge of δ derived from the angle the complex pole makes with the real axis.

We know the poles move in the complex frequency plane for varying gain. It is possible to plot the path which these poles follow for various values of gain. This technique is called the Root Locus Plot, and will be discussed in the next article of this series.

(TO BE CONTINUED)

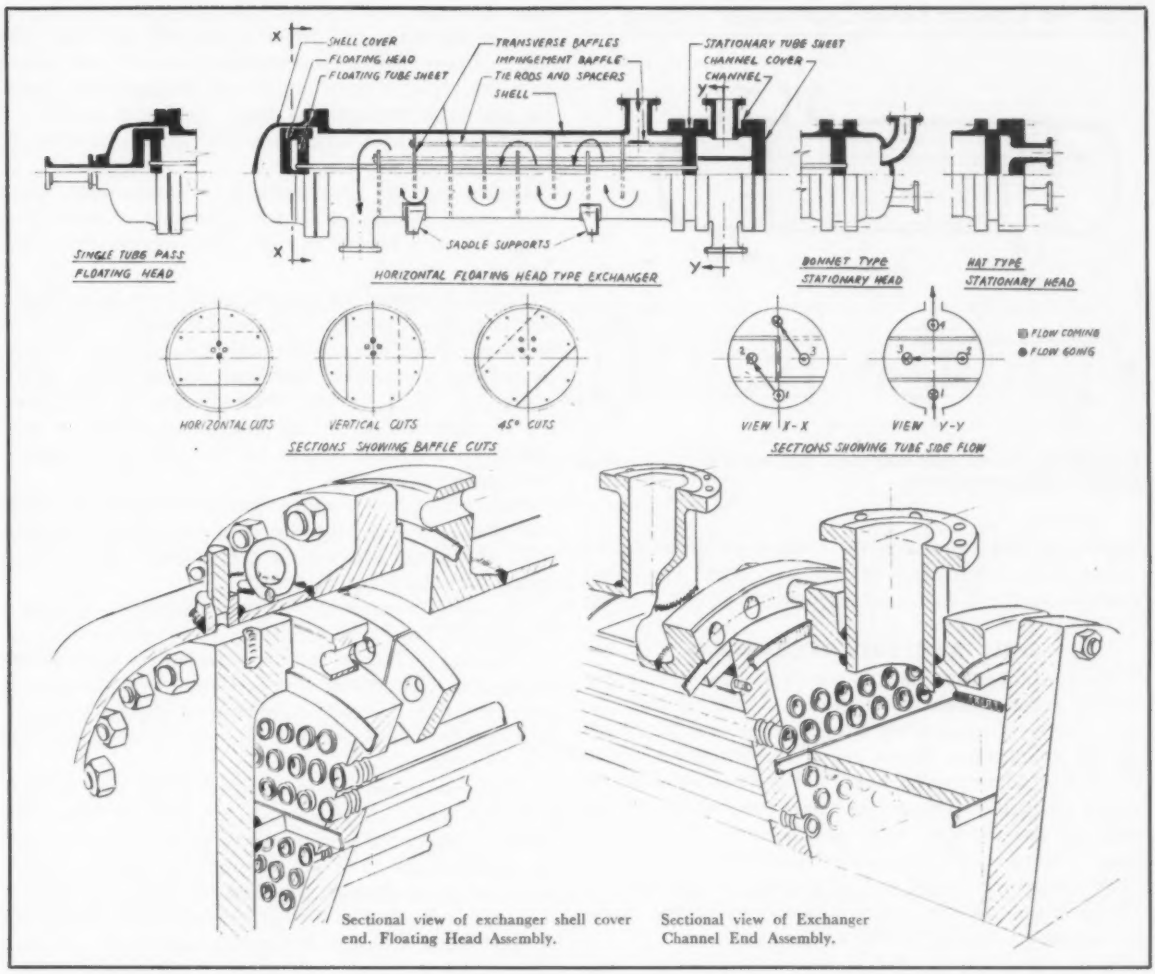


FIGURE 1—These sectional views show typical exchanger components used in refineries and petrochemical plants.

How to Design Heat Exchanger Piping

By following these details when designing exchanger piping, good access, ease of maintenance and better operation will result

Robert Kern, New York City

EXCHANGER PIPING represents a large portion of process unit piping cost. This article presents the details of exchanger layout and piping design, showing how to save material and labor cost beside making quick and systematic exchanger piping design.

Piping connected to heat exchangers is generally simple. Piping economy and good engineering design depends more on knowing what alterations can be made to exchangers than on actual piping design know-how. In other words the piping designer can influence the exchanger design (direction of flow, nozzle location, etc.) in the interest of a better, more functional piping design. Alterations to exchangers, of course, should not affect their duty and cost. Money saved in simpler piping should not be spent on making costly alterations to exchangers.

In order to know what changes and alterations can be contemplated to heat exchangers and to evaluate alternative possibilities of exchanger piping, the designer must know the construction details of exchangers, the wide range of exchanger types, functions and duties of exchangers in petrochemical plants. Only with this

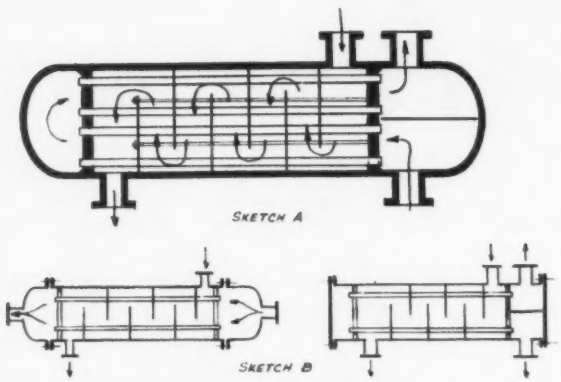


FIGURE 2—Shows fixed tube sheet exchangers for use in clean and low temperature service.

knowledge can he design the most economical piping arrangements, satisfying engineering, plant operation, maintenance and safety requirements.

SHELL AND TUBE EXCHANGERS

Most exchangers used in petrochemical plants are welded constructions. See Figure 1. Shells are built up as a piece of pipe with flanged ends and necessary branch connections. Shells are of seamless pipes up to 24 inches diameter, or bent and welded steel plates above 24 inches. Channel sections, too, are usually of built up constructions with welding neck forged steel flanges, rolled steel barrels and welded-in pass-partitions. Shell covers are either welded directly to the shell or are built up construction of flanged and dished heads and welding neck forged steel flanges.

Inlet and outlet nozzles, on both tube and shell side, are arranged to give the required flow through the unit with optimum heat transfer conditions. The shell and channel has vent and drain connections; in and outlet nozzles usually have temperature connections. Pressure, gage glass, level controller, relief valve connections can also be arranged on the shell if required.

The internal of an exchanger consist of tubes with tube sheets and baffles. Tubes are in square or triangular arrangement and roller expanded into the tube sheets. Cross baffles are one-eighth inch to one-fourth inch thick plates suitably cut and arranged for directing the flow through the shell. The tube bundle fits closely in the shell without interfering with tube bundle removal.

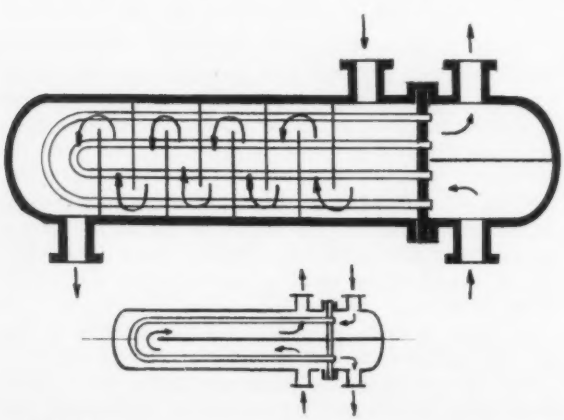


FIGURE 3—U-tube exchangers provide for expansion at one end of the bundle.

Exchangers are constructed in a great variety for a wide range of purpose. The combination of many kind of shells, shell covers and channel sections, tubes and baffles are possible.

Figure 2 shows exchangers with fixed tube sheets. Exchangers with completely enclosed tubes can be used in clean service only. (sketch A) Cleaning can be done by flushing through the tube and shell side. Two bolted covers (sketch B) facilitate easier inspection and cleaning of tube insides. As no provision is made for tube expansion these exchangers are built for low temperature service.

Figure 3 shows U-tube exchangers. Here the tubes can freely expand and the tube bundle is removable from the shell. This exchanger is used when fouling inside the tubes is not expected.

The most often used type in petrochemical plants is the floating head type exchanger. Basic design is shown on Figure 1. This is a more expensive type of exchanger than the fixed tube or U-tube type. Tubes can freely expand; channel, channel head and shell cover is provided for convenient inspection, tube bundle removal and cleaning.

In case of single pass tube the floating head cover is extended with a tube through the channel head (See Figure 1. upper left corner). Leakage is possible through the packing and it is not advisable to put flammable liquid or gases through the shell for safety reasons.

Figure 4 shows a tabulation of typical heat exchanger arrangements. Column A shows a typical picture with basic nozzle locations and baffle arrangements, column B indicates the type of tube bundle, column C gives brief construction designation, column D typical duties. Terminology for the various typical functions are listed on Figure 5.

Exchanger type, size, construction details, nozzle arrangements, flow direction through shell and tube is determined by the exchanger designer, without taking into account external piping arrangements. The piping designer usually has no influence in the basic design and selection of the various types of heat exchangers. However, he can request alternate flow and nozzle arrangements in the interest of more economical and better engineered piping. Figure 4 column E lists possible alternate flow and nozzle arrangements to basic design.

Thermal design and sizing of exchangers is based on the well known formulae of

$$Q = U.A.(\Delta T)$$

where Q = total heat transferred in BTU/hr

A = area of retaining wall between the two flowing media in sq. ft.

ΔT = Temperature difference, °F between the two media. (Logarithmic mean temperature difference is used with commonly accepted calculations.)

Q and ΔT are based on process requirements and

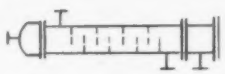
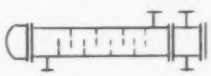
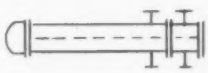
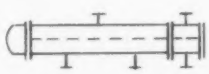
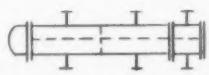
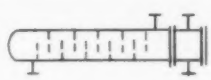
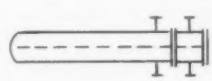
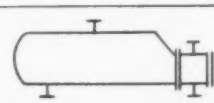
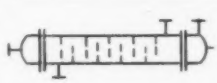
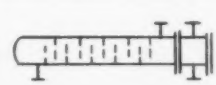
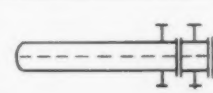
	A	B	C	D	E					
Key Nos.	Typical Heat Exchanger Arrangements	Type Of Tube Bundle	Construction Designation	Typical Use (For Terminology And Typical Functions See Fig. 5)	Possible Alterations To Typical Arrangements Without Affecting Thermal Design					
						Change Direction Of Flow On			Change Nozzle Location	
					Inter Change Flow Media	Shell Side Only	Tube Side Only	Both Sides Same Time	Turn Tube Side Noz. Radially 180°	Turn Shell Side Noz. Radially 180°
1		Floating Head	Single Pass Shell – Single Pass Tubes	Exchanger Cooler Heater	✓			✓	✓	✓
2			Single Pass Shell - Two Or Four Pass Tubes		✓	✓	✓	✓		✓
3			Double Pass Shell - Two Or Four Pass Tubes		✓			✓		
4			Single Split Flow Shell – Two Or Four Pass Tubes	Condenser Evaporator Reboiler			✓			
5			Double Split Flow Shell - Two Or Four Pass Tubes				✓			
6		U-Tubes	Single Pass Shell - Two Or Four Pass Tubes	Exchanger Cooler Heater (In Clean Tube Side Service)	✓	✓	✓	✓		✓
7			Double Pass Shell - Two Or Four Pass Tubes		✓			✓		
8			Kettle Type Reboiler	Reboiler Steam Generator Vaporizer						
9		Fixed Tubes	Single Pass Shell – Single Pass Tubes	Exchanger Cooler Heater (In Low Temperature Clean Service)	✓			✓	✓	✓
10			Single Pass Shell - Two Or Four Pass Tubes		✓	✓	✓	✓		✓
11			Two Pass Shell - Two Or Four Pass Tubes		✓			✓		

FIGURE 4—This tabulation of typical exchangers shows possible alterations for better piping.

Terminology and typical functions of shell and tube heat exchangers . . .

EXCHANGER

Heats one stream and cools the other. There is no heat loss, and physical change does not take place in the flowing media.

COOLER

Water cools liquid or gases without condensation. (Other designations: intercooler, aftercooler.)

SUBCOOLER

Condenses vapor with water and cools further the condensed liquid.

CONDENSER

Condenses vapor or vapor mixture. Condensers can be water cooled, which means the transferred heat is lost. Or sufficiently cold process stream can be heated while condensing the other process stream; consequently, there is no heat loss.

CHILLER

Uses refrigerants for cooling process stream below freezing point or below prevailing cooling water temperature.

HEATER

Heats process stream generally up to its boiling point and without appreciable vaporization. Heater medium is usually steam or sometimes dowthern. (Other designations: preheater.)

REBOILER

Reboil the bottom stream of tower for the fractionation process. Heating medium is generally steam or a hot process stream. When large quantities of vapor has to be produced the kettle type reboiler is used.

WASTE HEAT BOILER

Uses waste heat (for example gas-turbine or diesel engine exhaust gas) for steam generation.

STEAM GENERATOR

Uses heat of process liquid or gas for producing steam.

VAPORIZER

Vaporizes part of a process liquid stream. (Other designation: evaporator.)

FIGURE 5

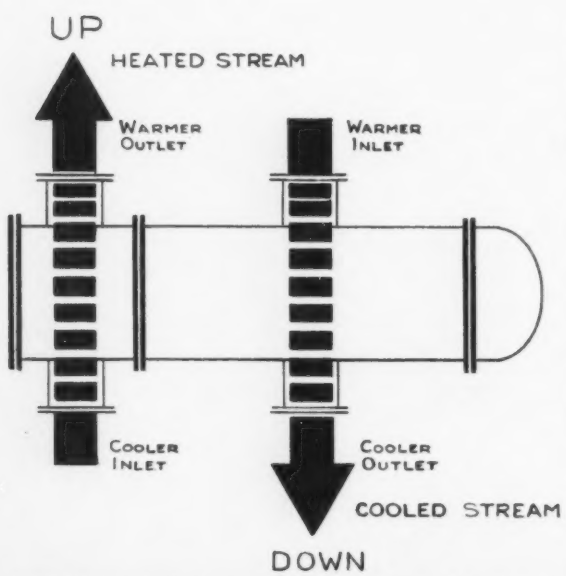


FIGURE 6—Standard arrangement of flow in exchangers with heated stream up and cooled stream down.

U = heat resistance coefficient, BTU/hr/sq. ft./°F.

U is the function of many variables. Its proper selection is the duty of an experienced exchanger designer.

"A", then, can be calculated and the calculation expressed in size, number and length of tubes required and the selection of a standard exchanger can be made.

For the piping designer the most important symbol is "U", because each time he wants to change the flow direction in an exchanger or reposition a nozzle in the interest of better piping this coefficient can be affected. In turn, this can affect the exchanger's efficiency and thermal design. Consequently, at each contemplated change the piping designer should consult a competent exchanger designer.

FLOW CHANGES FOR BETTER PIPING

It has been mentioned above what is basically involved in making alterations to heat exchangers. In the following two further principles of heat transfer are outlined which are helpful when doing exchanger piping design.

Figure 6 illustrates the first such principle. In words: generally, in heat exchangers the heated media should flow up and the cooled one should flow down. This, of course, is the simple physical behavior of any heated or cooled media. This rule is more important if in the flowing media physical change takes place while passing through the heat exchanger (evaporation, condensation). Where liquid or non-condensing gases pass through the exchanger this rule becomes a preference only.

This is why in most cases water inlet is at the bottom side of exchangers. Similarly reboiler inlets are at the bottom side of exchangers and outlets at the top. And steam enters at the top channel nozzle of reboiler and condensate leaves at the bottom channel nozzle. Condenser vapor inlet is at the top and liquid outlet at the bottom.

Where large quantities of vapor have to be condensed or released, the physical change takes place usually in the shell where more volume can be provided than in the restricted space of tubes.

The second heat transfer principle—counterflow gives better heat transfer than concurrent flow and is preferred. This, of course, can only be fully satisfied with single pass exchangers on both the tube and shell side or with double pipe heat exchanging units. In case of multipass tubes with crossflow shells this second principle loses its importance.

For better piping arrangement alterations to heat exchanger construction can be made without cost increase. These possible alterations—which practically will not affect thermal design—are listed on Figure 4, column E and checked against typical heat exchanger arrangements. (Unchecked items are sometimes also possible, but can affect thermal design more seriously. These cases must be investigated with an exchanger designer.)

Six possible alterations which can be made to exchangers are:

Interchange flowing media between the tube and shell side. This change is often possible, more so when

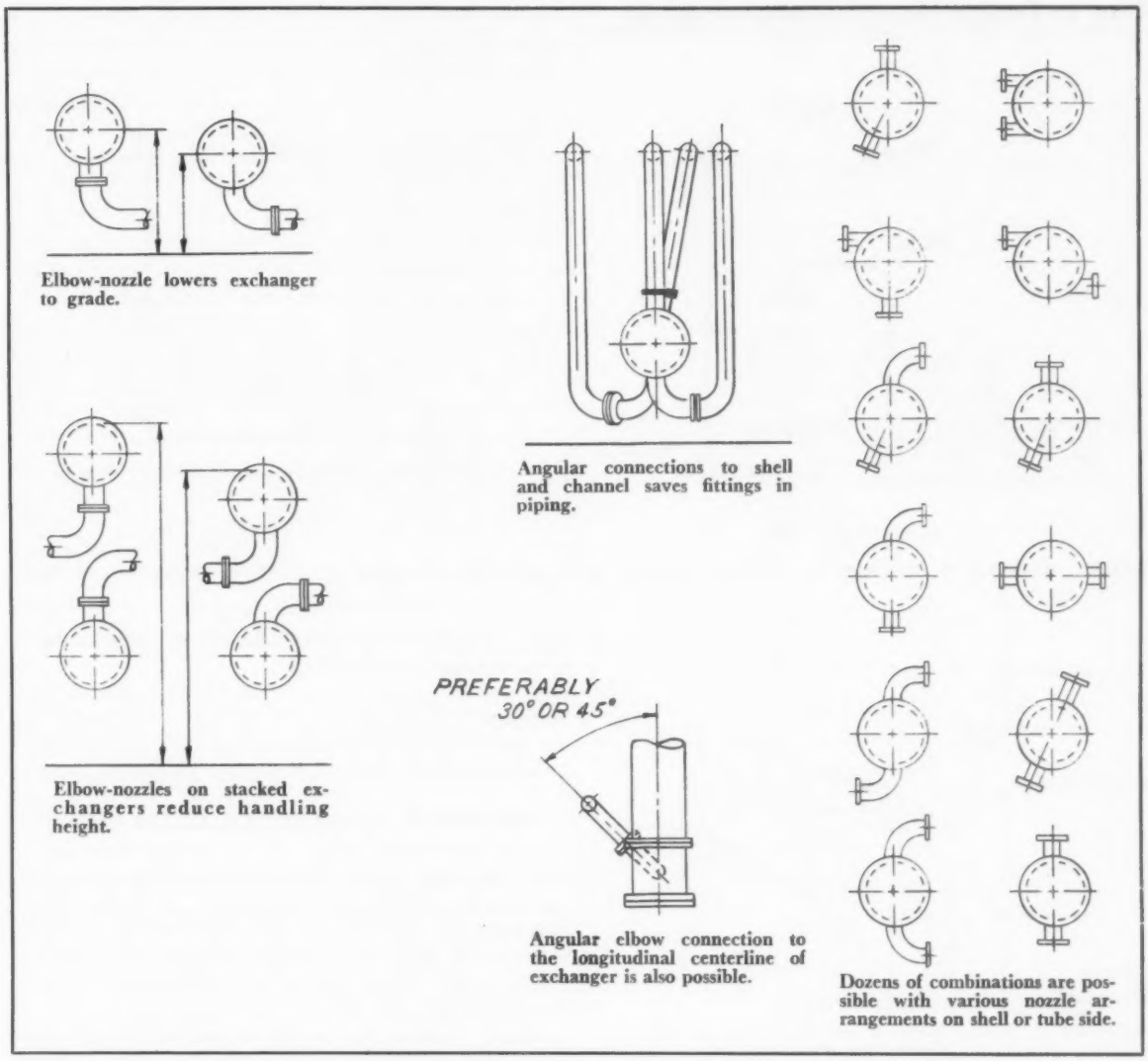

Elbow-nozzle lowers exchanger to grade.
Angular connections to shell and channel saves fittings in piping.
Elbow-nozzles on stacked exchangers reduce handling height.
PREFERABLY 30° OR 45°
Angular elbow connection to the longitudinal centerline of exchanger is also possible.
Dozens of combinations are possible with various nozzle arrangements on shell or tube side.

FIGURE 7—Here are a number of variations for nozzle arrangement for better piping.

the flowing media are similar, e.g., liquid hydrocarbons. Preferably, the hotter liquid should flow in the tube to avoid heat losses through the shell or to avoid possible thicker shell insulation.

Change direction of flow (a) on tube side, (b) on shell side or (c) on both sides. These changes are frequently possible and are accepted by the exchanger designer if the exchanger tubes are in double or multipass arrangement and the shell has a cross flow arrangement. In exchangers where counterflow conditions can be arranged changing of flow direction should be made simultaneously in tube and shell.

Change exchanger nozzle location on (a) tube side, (b) shell side. On most exchangers in petrochemical plants these changes are also frequently possible on the shell and channel without affecting the required duty of the exchanger.

Combinations of above alterations at certain exchangers are also possible. For example one can change flow direction and nozzle location at the same time on the exchanger shown under item 2 on Figure 4.

Additional points which also can influence the piping designer's decision regarding changes in exchanger construction are—

Shell Leakage. When watercooling gases, liquid hydrocarbons or chemicals, the water usually passes through the shell. A possible tube leakage will contaminate the water instead of leaking to the atmosphere where it can become dangerous.

Pressure. Sometimes it is more economical to have higher pressure in the tubes than in the shell to have minimum shell wall thickness.

Corrosion. Corrosive liquids should pass through the tubes so that the shell can be made of carbon steel.

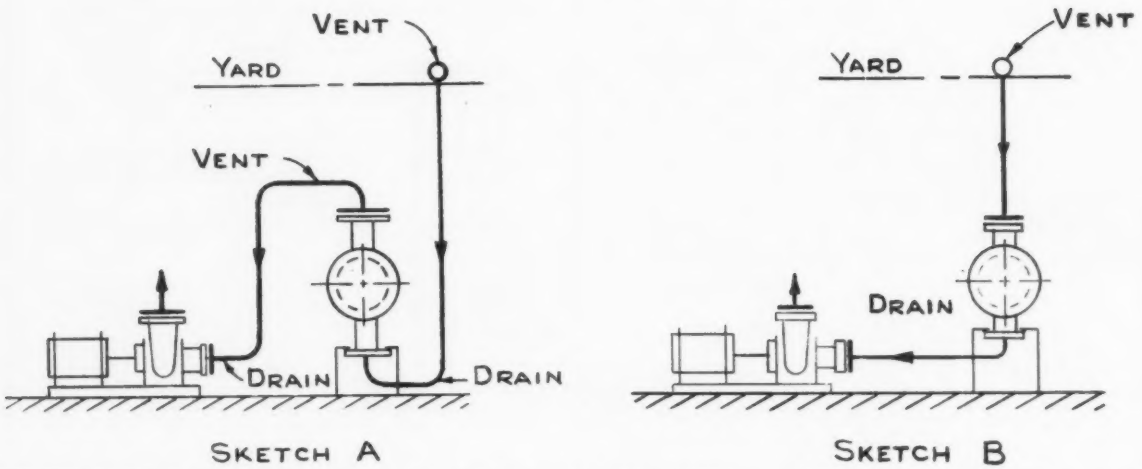


FIGURE 8—Sketch A may work but sketch B is better and is achieved by changing flow direction through the exchanger.

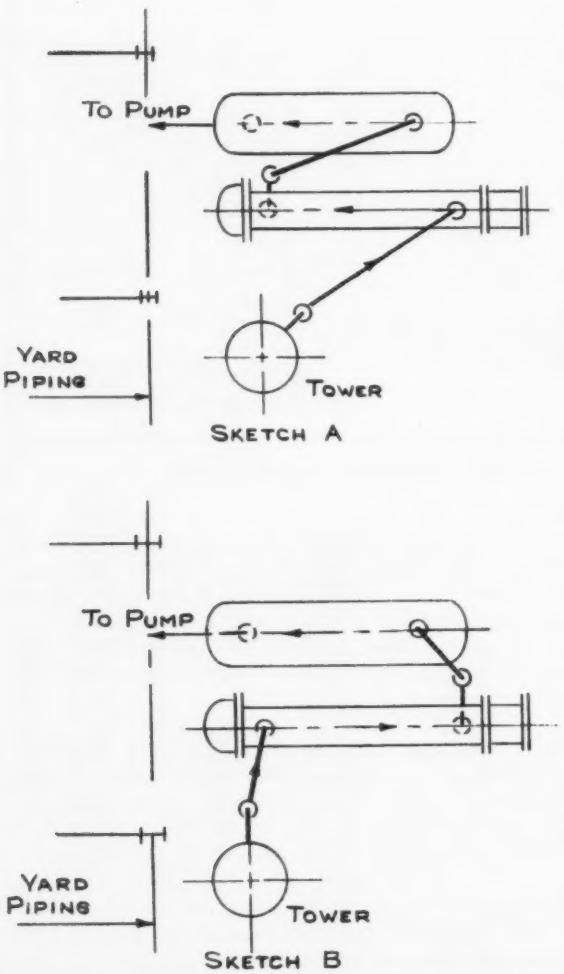


FIGURE 9—Sketch A shows zig-zag flow pattern which should be avoided. Sketch B shows how relocating nozzles can provide a more functional flow pattern and shorter piping.

Only the tubes and channel has to be manufactured of more expensive alloy steel.

Fouling. If one media is dirty the other clean, passing the clean through the shell will result in an easier tube bundle removal or even a simpler exchanger design.

MECHANICAL CHANGES FOR BETTER PIPING

In the interest of saving cost, providing better access and improving piping layout, mechanical alterations can also be made to the basic exchanger design. These alterations do not affect the thermal design and can be made to all types of exchangers. Often slight cost increase caused by special nozzle arrangement is more than offset by more economical piping.

Figure 7 shows frequently adopted nozzle arrangements on exchangers. Elbow-nozzles permit lowering exchangers closer to grade. Stacked exchangers in parallel or dissimilar service can be arranged closer, with elbow-nozzles between them. This facilitates better access to exchanger valves and instruments besides easier maintenance.

Angular connections can save one or two bends in the pipe line. These connections are more often applied to top nozzle of shell or tube side. Excessive angular connection at the bottom can mean a separate drainage point on the shell or channel. The maximum angle from vertical centerline can be about 30°. This angle depends on nozzle and shell size and internals of the exchanger: baffle arrangement in the shell and partitions in the channel.

Tangential connections are more expensive to make but can save fittings, make piping arrangement simpler and improve access to valves.

BETTER PIPING DESIGN

Many design combinations are possible and are adopted in petrochemical plants. A piping designer can visualize

an exchanger as a large diameter pipe with branch connections and he can design virtually anything which is possible with pipe fittings, within the limitations of exchanger constructions.

Why do all these details interest a piping designer? He is not only responsible for the physical arrangement of piping but also for the efficient and trouble free operation of process equipment including exchangers. For example, if he blindly follows an exchanger designer's nozzle locations and flow requirements he can end up with a piping arrangement shown in Figure 8, Sketch A, having a pocket and a loop in the line, which means longer line, more fittings, more vents and drains, longer pump suction with an undesired loop. Figure 8, Sketch B, has been obtained by reversing the flow in the system, which means a better engineered and more economical piping layout. A loop, pocket, vent and drain have been eliminated. Friction losses through the piping system have been reduced and pump suction shortened and simplified.

Another example is shown in Figure 9. Relocating nozzles on the exchanger shell (Sketch B) results in a simpler piping arrangement than shown on Sketch A.

Information Required. Being familiar with heat exchangers is only part of a piping designer's know-how. The understanding and proper interpretation of process and project design data is also important. These data are supplied to the piping designer and are listed in order of importance in the followings:

1. Specifications refering to details connected with (a) exchanger design (minimum shell size, type of exchanger, etc.) (b) exchanger handling requirements (tube bundle removal, handling steel requirement for elevated exchangers) (c) piping design (headroom, access, valving, etc.) (d) special plant requirements (local regulations safety codes.)

2. Flow diagrams. The proper evaluation of flow diagrams is perhaps the most important function of the layout engineer and piping designer. The process flow diagram tells: (a) basic information for exchanger design: what medium is flowing, flow rates, temperatures and other physical data. (b) basic details for piping design: pipe sizes can be calculated, temperatures of piping is shown, interconnected equipment with exchangers are shown, main pipe runs can be visualized, elevations of exchangers can be assessed. Process control diagrams show required instrumentation. Mechanical flow diagrams developed from process flow and control diagrams, show the complete process and utility piping systems and details, as well as instrumentation.

3. A plot plan is developed basically from the process flow diagram and other plant layout requirements. The plot plan gives the location of heat exchangers with adjacent equipment, also relationship with access roads and yard piping.

Specifications, flow diagrams and plot plan are suffi-

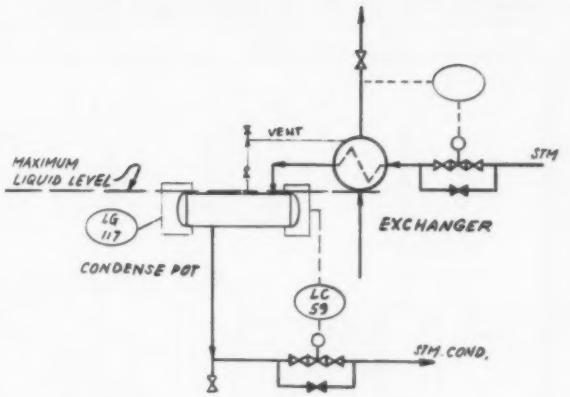


FIGURE 10—With exchanger elevated just above condensate pot, flooding of tubes can be avoided.

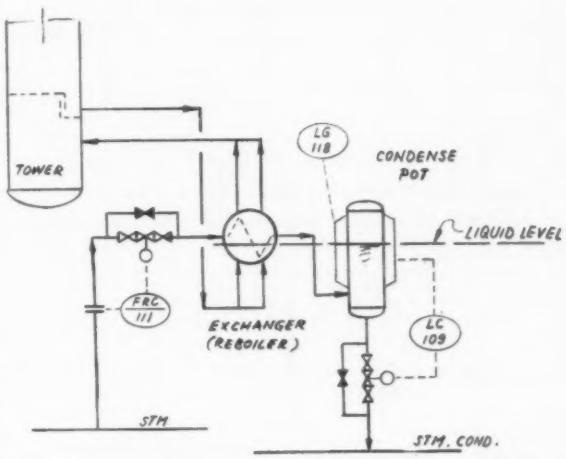


FIGURE 11—When holding a liquid level in an exchanger the precise relationship is provided by the process engineer.

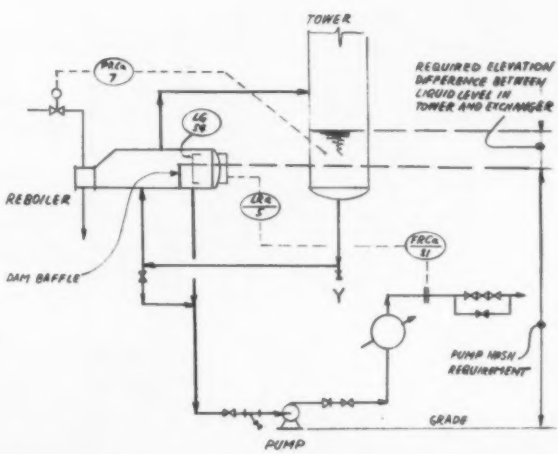


FIGURE 12—When reboiler is elevated because of pump NPSH, then the reboiler sets the tower elevation.

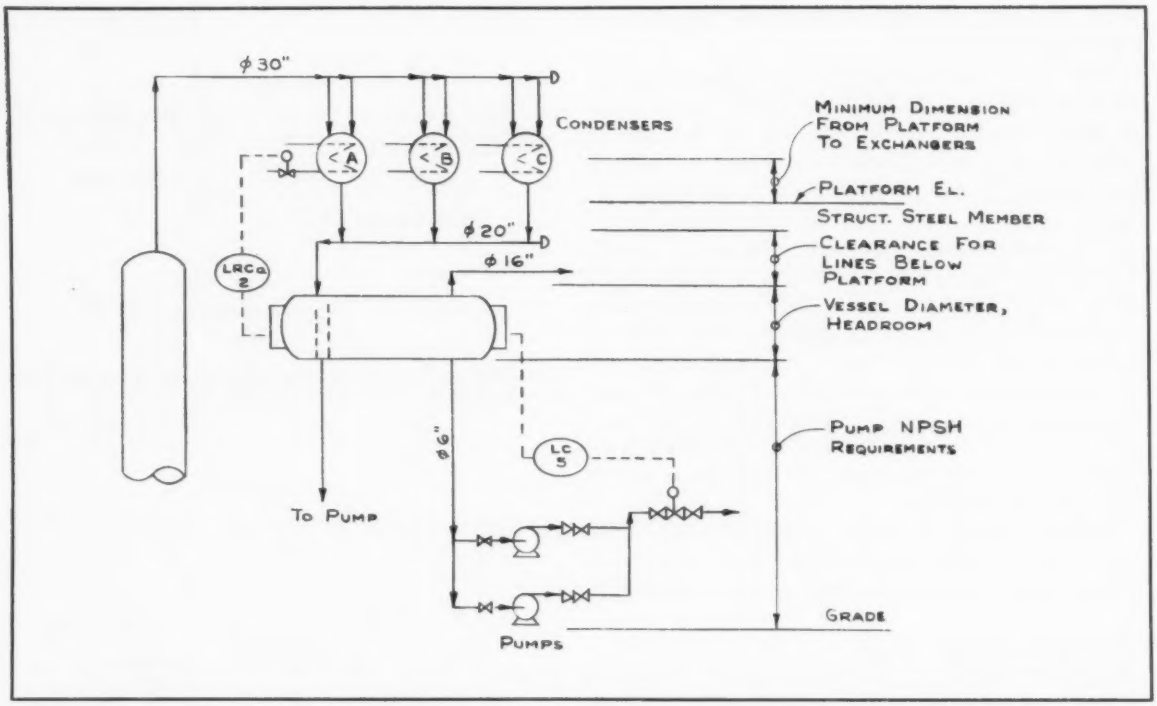


FIGURE 13—Factors shown on the side of this figure determine elevation of exchangers when gravity flow is required.

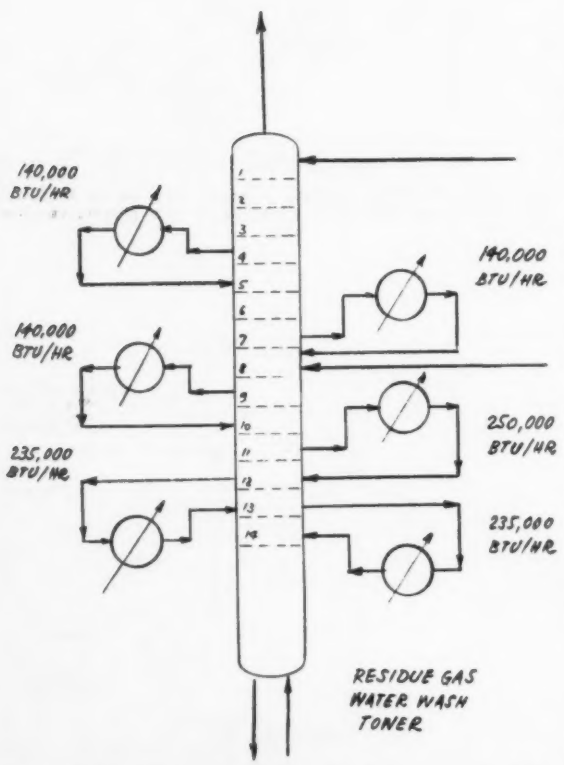


FIGURE 14—When coolers in gravity flow are required they should be located above the respective tower inlet.

cient for initial design. Design ideas can be produced, piping visualized and details arranged.

4. Exchanger drawings and data sheets give all the details of exchanger design. Size, type, number of units, nozzle arrangements, weight of bundle, exchanger internals, tube and baffle arrangements.

Suggestions can be made for locations and alterations of exchanger footing, nozzles, and instrument connections; similarly, possible changes in direction of flow through the heat exchanger can be evaluated.

These suggestions of changes should be made at an early stage of design, because it affects exchanger design, fabrication and delivery schedules.

5. Process data is required indicating the elevation of exchangers relative to grade or other equipment.

6. Instrument sketches showing the location of instrument connections to the exchanger for level gauges, level controllers, pressure and temperature connections when required.

7. Manufacturers catalogues or standard drawings are required for the physical details of instruments, equipment and pipe accessories.

8. Insulation details of exchangers and piping are also required.

This information is all necessary to make plant layout and exchanger piping arrangement. The customer's requirements written in the specifications have to be remembered and applied. The exchanger unit with all

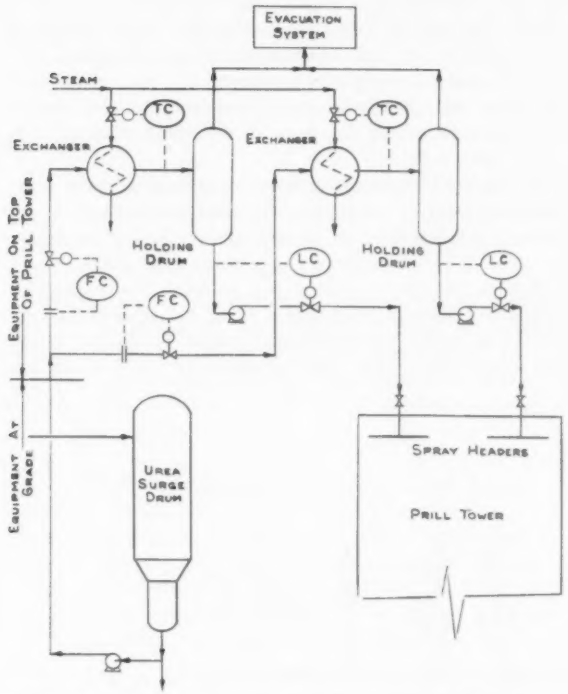


FIGURE 15—In this urea prilling system, exchangers were elevated to the holding drum level for close temperature control.

its piping, valving and instruments should be a functional part of the plant, properly laid out with respect to related equipment, access and bundle removal space as shown on the plot plan. Piping systems should conform to all details as presented in the flow diagrams. Exchanger drawings, instrument sketches and catalog will also influence the arrangement of exchanger piping.

What Elevates an Exchanger

1. Most exchangers are at grade with centerline elevations of about 3.0 to 5.5 feet above ground level for exchangers about 1 to 3 feet in diameter. Exchangers at grade are the most economical arrangements. Most valves and instruments can be made accessible from grade, tube bundle handling is convenient and maintenance easy.

2. Some exchangers have a condensate or liquid holding pot after one of their outlets. In such case the centerline elevation from grade must be more carefully chosen. These exchangers may have somewhat higher elevations than those at grade without a condensate pot.

Figure 10 shows an example. This arrangement is really a high capacity steam trap. In the layout the top of the condensate pot should be at least in line with the bottom of exchanger to avoid flooding the tubes with condensate and adversely affecting the exchanger heat transfer duty.

Figure 11 is another example. Here holding of liquid level in an exchanger was required. The precise relationship between the exchanger and "control pot" is

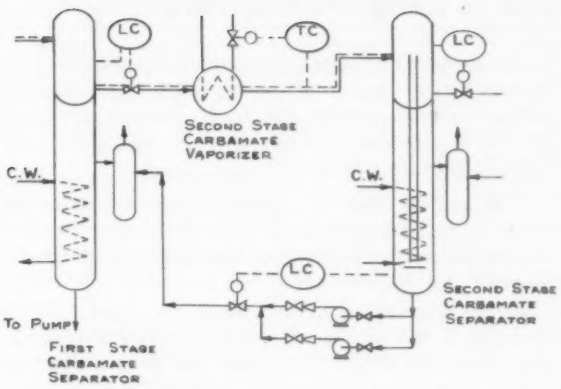


FIGURE 16—In certain cases it is less expensive to locate exchangers high on a tower than provide pumps and necessary piping.

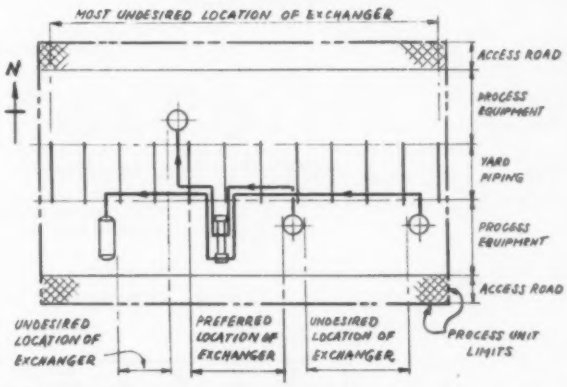


FIGURE 17—This is a good layout when enterchangers must be provided between two pieces of equipment.

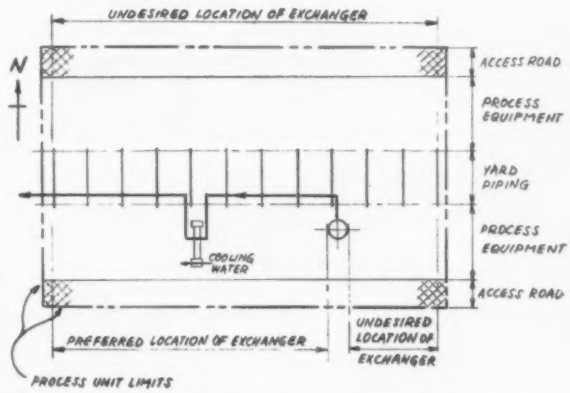


FIGURE 18—Product coolers should be located along the way to the battery limit.

important and should be given by the flow system engineer for the physical layout.

3. Figure 12 shows an example where a reboiler has been elevated by the NPSH requirement of a centrifugal pump. Such arrangement can elevate an exchanger from 5 to 18 feet. In most cases access to valves, instru-

ments, exchanger flanges, tube removal platforms, trolley and trolley beam must be provided. (This elevated reboiler in turn elevates the tower, because the liquid level in the bottom of tower must be higher than the liquid level in the reboiler.)

4. If gravity flow is required from the condenser outlet to a collecting drum, reflux drum or separator, exchangers must be elevated. Examples are shown on Figure 13 and Figure 14.

At the condensing-reflux system in Figure 13 the elevation of the condensers is influenced by several factors. First, the reflux drum must be elevated because of pump NPSH requirement, say 14 feet to the bottom of drum (about 2-3 feet below this elevation a platform is required). To this 14 feet, the drum diameter, estimated space for pipe lines, depth of structural steel members plus platform-to-exchanger-centerline dimension must be added for establishing the exchanger elevation above grade.

In general, in vacuum service and in certain fractionating services, where close pressure control is required, condensers are placed above the reflux drum. In most of cases condensers are located at grade.

Figure 14 shows coolers in a gravity flow system. If available pressure difference is small between exchanger inlet and outlet the exchangers must be placed above the respective tower inlet nozzles. In such cases ex-

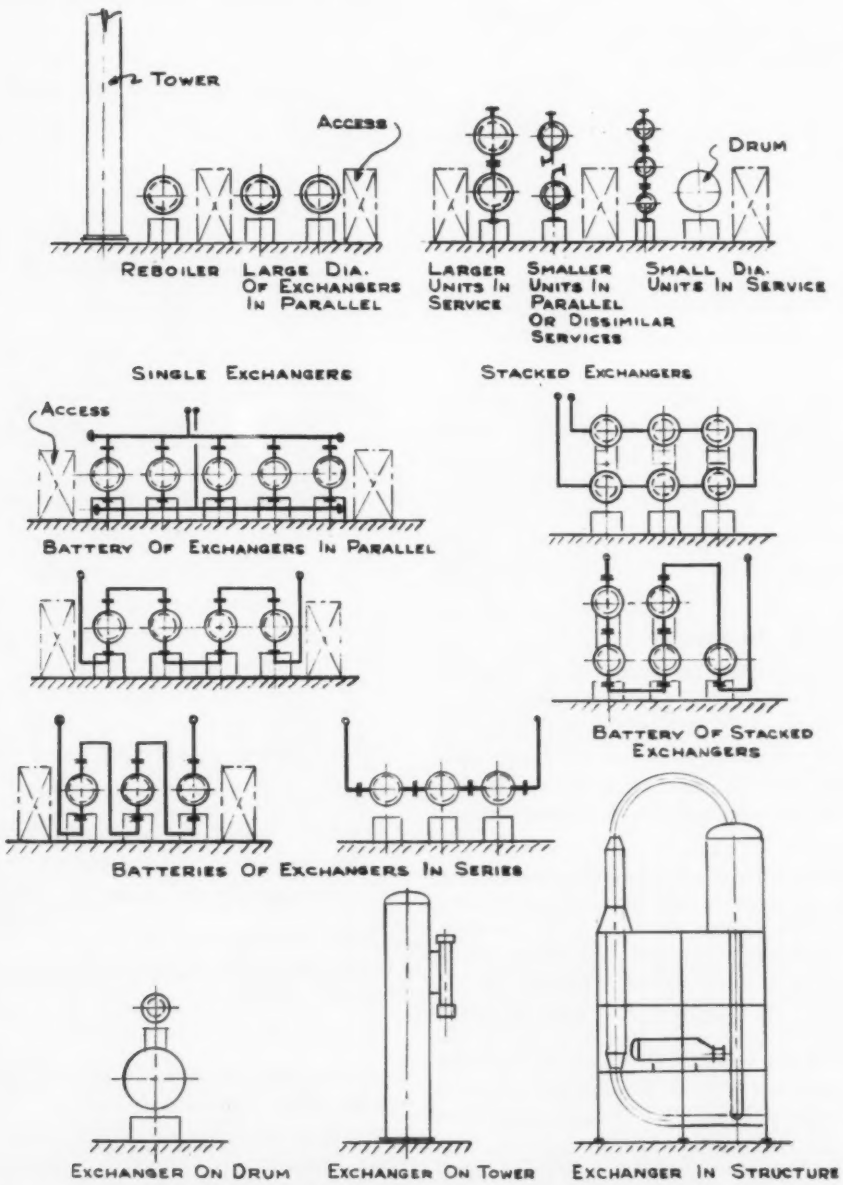


FIGURE 19—These typical exchanger groupings are useful in providing access for instruments, controls and process piping.

changers are placed either on an adjacent structure or supported (preferably vertically) from the tower. Sometimes. the piping designer can suggest a pump in such circuits if supporting the exchanger becomes expensive. A pump in the circuit, of course, will bring the exchanger to grade.

5. Exceptional processes requirements can also elevate exchangers. Assessment of elevation from a flow diagram is difficult. Required conditions must be specified by the flow system designer.

In Figure 15 close temperature control in the flowing liquid was required. The liquid was near its solidifying point and was kept just flowing until forced through sprayers for prill formation. The whole arrangement of exchangers, holding drums and pumps were arranged on a high prill tower.

6. Finally, exchangers can be elevated because of layout reasons. There was sufficient pressure in the system shown on Figure 16 to place the exchanger at grade. Investigation showed it was more economical to support the small diameter exchanger on one of the adjacent towers, than to leave it at grade. This saved jacketed piping between the exchanger and towers.

Generally, these points elevate exchangers. However, the necessity of elevating exchangers should be carefully investigated and alternative possibilities cost-evaluated. It is expensive to provide supporting steel, access and handling steel, to elevated exchangers.

LAYOUT OF EXCHANGERS

Layout arrangement of exchangers can also affect piping design. Process equipment in most plants are arranged in the sequence of process flow. However, whatever layout system is used the general evaluation regarding exchanger positions is very similar.

In layout the fractionation towers should be arranged first and other equipment after the proper tower sequence had been established. The position of an exchanger in petrochemical plants usually depends on the position of towers or, sometimes, on other process equipment. This relative position of exchangers can be readily evaluated from flow diagrams. For exchanger positions in a petrochemical plant the following general classification can be made.

1. Exchangers which must be next to other Equipment. Such exchangers are the reboilers which should be located next to their respective towers. Or condensers which should be next to their reflux drums close to the tower.

2. Exchangers which should be close to other process equipment. For example exchangers in closed pump circuits such as some reflux circuits. Overhead condensers should also be close to their tower. In case of tower-bottom-draw-off-exchanger-pump flow, exchangers should be close to the tower or drum, to give short suction lines.

3. Exchangers located between two distant items of

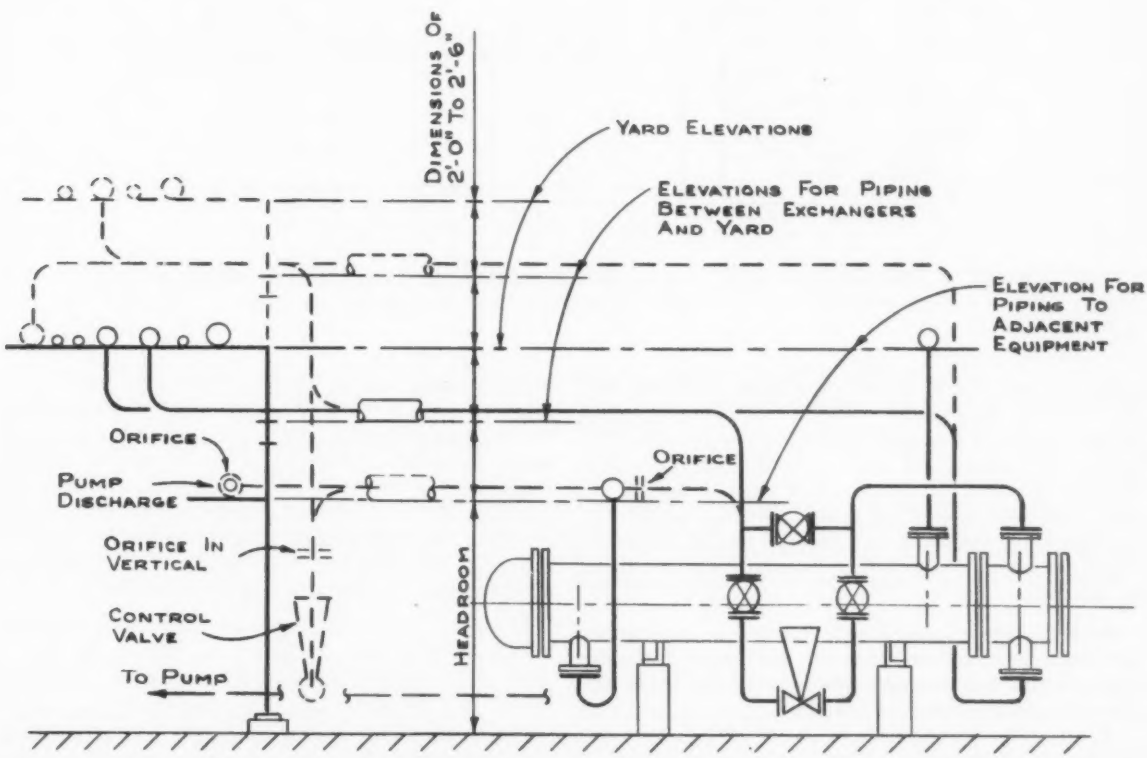


FIGURE 20—Shows an exchanger in elevation with adjacent process equipment and single level yard piping.

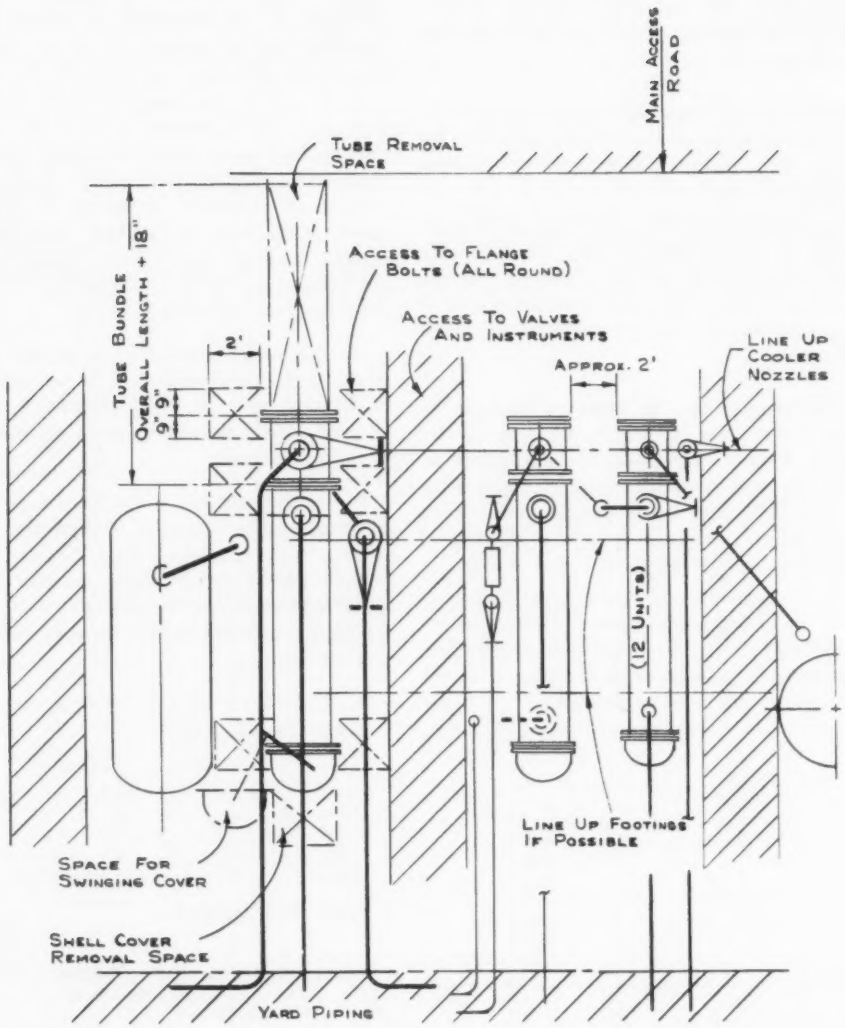


FIGURE 21—This plan view shows provision for tube bundle removal with minimum removal of piping.

process equipment as shown on Figure 17. These are, for example, exchangers with process lines connected to both shell and tube side. Where the two streams meet in the yard piping and have a parallel run is the preferred location of exchanger. And on that side of the yard, where the majority of related equipment is placed. In Figure 17, the south side because the three related items are on this side. Other locations will cost more in pipe runs.

4. Exchangers located between process equipment and the unit limit, as shown on Figure 18. Such exchangers are for example product coolers. These are frequently located near the unit limit.

Stacked Exchangers. A further step in the layout is to establish which exchangers can be stacked for simplifying piping and saving plot space. Most units in the same service are grouped automatically. Two exchangers in series or parallel are usually stacked. Sometimes, small diameter exchangers in series can be stacked three high. Two exchangers in dissimilar services can also be stacked. Sufficient clearance must be provided for shell and channel side piping between the two exchangers. Reboilers and single condensers usually stand by themselves beside their respective towers.

Company specifications usually limit the maximum height of exchangers to about 12 feet to the top of shell, so that mobile plant equipment can conveniently handle tube bundles.

Figure 19 shows typical exchanger groupings. It is sufficient to provide access only on one side of exchangers for valves and instruments. Pairs or batteries of

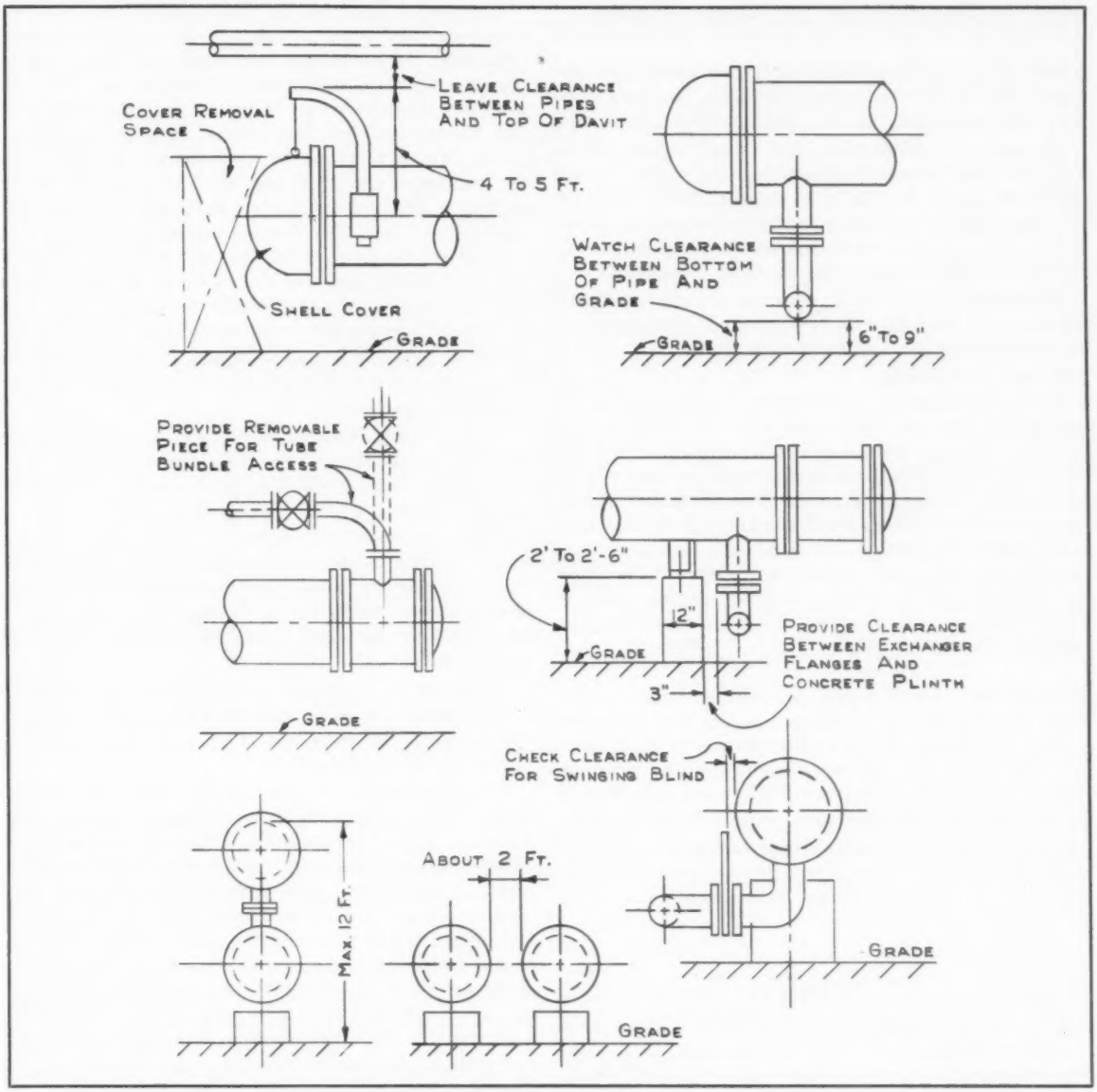


FIGURE 22—By carefully following these sketches of piping arrangement many problems can be avoided.

exchangers are spaced with about 2 feet clearance between the outside of channel flanges.

HOW TO ANALYZE EXCHANGER PIPING

In Elevation. After all information has been collected, exchangers located in the plant and elevations established, the next step is to outline clearance and working space requirement around both ends of the heat exchanger. These working spaces should be kept clear of any piping and accessories to facilitate channel, shell cover and tube bundle removal; maintenance and cleaning. (These clearances are shown in Figure 21 for about a 2 foot shell diameter exchanger. Smaller units will require somewhat less and larger ones slightly more clearance.)

Beside providing adequate access, piping requirements result in simple and well organized physical arrangement giving three dimensional reality to the piping systems and details presented in the mechanical flow diagrams.

Figure 20 shows an exchanger in elevation with adjacent process equipment and single level yard piping. The main elevation for lines between the exchanger nozzles and yard piping is about 2 to 3 feet lower than the yard elevation. It is frequently preferred to have steam lines connecting to the top of the header to avoid condensate drainage towards the exchanger. (With steam traps at the low point there is nothing wrong in having steam connections to the bottom of header.) This elevation can be used for pump discharge lines, if the pump is under the yard piping and near the exchanger, and for lines connecting to equipment arranged below the yard.

Pump suction lines from exchangers are just above

grade. In case of non-vaporizing liquids under pressure, pump suction lines can be run overhead; however, loopless (and pocketless) suction lines are always preferred.

In case of a double pipe yard two elevations can be used for lines between yard and exchanger. (See Figure 20 dotted lines.) But use only one supporting beam for all these lines at the lower or higher elevation depending on the number of lines supported. Hang or post-up one or two lines arranged on the other elevation.

Sometimes a flat turn at the edge of yard piping can be arranged. Of course, in such case the exchanger-yard interconnecting line will be elevated to the elevation of the main yard piping.

Lines interconnecting exchangers with other process equipment can run just above required headroom or about on the same level as the yard piping. Reboiler line elevations are determined by the draw off and return line nozzles on the tower. Symmetrical reboiler piping arrangements—between the tower draw off and reboiler inlet nozzles; similarly between reboiler outlets and return connection on the tower—are preferred for equal flow in the reboiler circuit. But non-symmetrical arrangements are also accepted to a more economical or more flexible piping design.

In Plan. The over-all plant layout already influences the main arrangement of exchanger piping and necessary access. (See Figure 21.) The channel end of exchangers face the main plant access for convenient tube removal. The shell cover faces the yard and should be as close to the yard steel as practically possible. (Usually 6 to 7 feet from column center to outside of shell cover.)

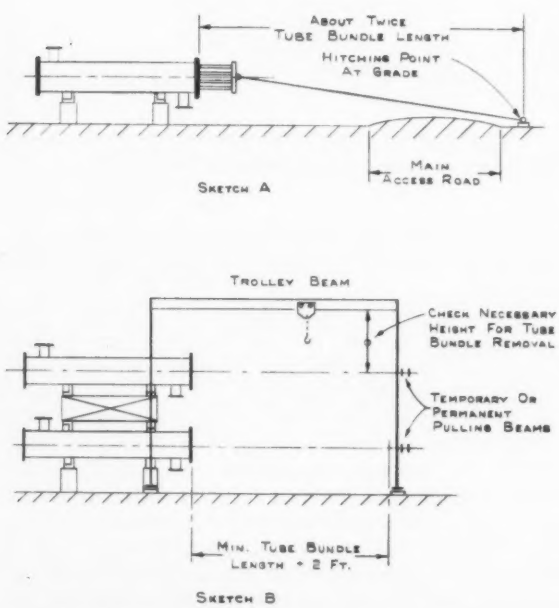


FIGURE 23—Typical tube bundle pulling arrangements. sketch B is better for stacked exchangers.

If piping is arranged on one elevation only between exchanger and yard piping one line will be located right over the exchanger center line. It is suggested to choose a top shell side nozzle for this location. The top tube side connection can be placed on a slight angle to miss the top shell side line without an offset in the line. Lines turning right in the yard should be right from the exchanger centerline and those turning left should approach the yard on the left hand side of exchanger center line. Lines from bottom connections should also turn up on the right or left side of exchangers depending upon which way the line turns in the yard. Lines with valves should turn towards the access aisle with valves and control valves arranged close to exchanger.

Utility lines connecting to a header in the yard can be arranged on any side of exchanger centerline without increasing pipe length.

Cooling water lines in most cases are below grade and should run right under the lined up channel nozzles of all coolers. Cooling water return header is usually adjacent to the cooling water line.

Access to valve headwheels and instruments will influence piping arrangement around heat exchangers. Valve handwheels should be accessible from grade and from a convenient access way. These access ways should be utilized for arranging manifolds, control valves and instruments.

In piping arrangement provision for tube removal access should also be provided. This usually means a spool piece or flanged elbow in the pipe line connecting to the top of channel nozzle.

The requirement of good piping layout in general apply to the design of heat exchanger piping. The shortest lines and least number of fittings—temperature permitting—will obviously provide the most economical piping arrangement. The designer should avoid unnecessary loops, pockets and crossovers. And he should investigate, nozzle to nozzle, the whole length of piping routed from the exchanger to some other equipment, aiming to provide not more than one high point and one low point, no matter how long the line. Very often a flat turn in the yard, an alternative position for control valves or manifold, changed nozzle location on the exchanger, etc., can accomplish this requirement.

Avoid excessive piping strains on exchanger nozzles from actual weight of pipe and fittings and from forces of thermal expansion.

For valves and blinds the best location is directly at the exchanger nozzle. In case of an elbow nozzle on an exchanger it should be checked that sufficient clearances are provided between valve handwheel and outside of exchanger. Elevated valves are usually chain operated. The chain should hang freely at an accessible spot near the exchanger. Figure 22 shows sketches highlighting exchanger piping details.

Orifice flanges in exchanger piping are usually in horizontal pipe runs. These lines should be just above headroom, and the orifice itself accessible with mobile ladder. When convenient lines with orifice and DP cell measuring element can be at grade. (Grade to pipe centerline dimension about 2½ feet.) Orifices in a liquid line and mercury type measuring element require more

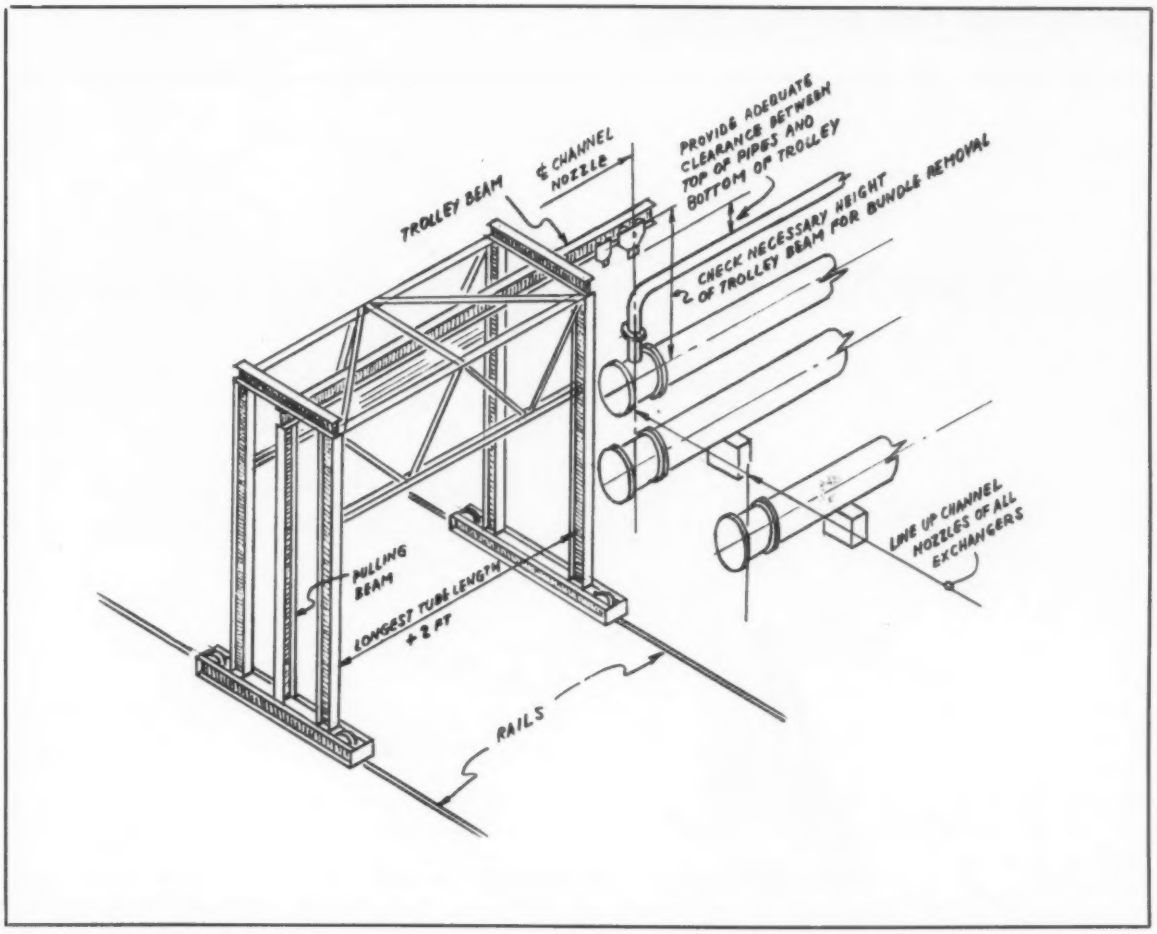

TROLLEY BEAM
℄ CHANNEL NOZZLE
PROVIDE ADEQUATE CLEARANCE BETWEEN TOP OF PIPES AND BOTTOM OF TROLLEY
CHECK NECESSARY HEIGHT OF TROLLEY BEAM FOR BUNDLE REMOVAL
LINE UP CHANNEL NOZZLES OF ALL EXCHANGERS
PULLING BEAM
LONGEST TUBE LENGTH + 2 FT
RAILS

FIGURE 24—Gantry crane can serve many exchangers for both removal and maintenance.

height. The long vertical measuring U-tube must be just below the orifice. At gas lines the U-tube can be above the line with orifice; height here, consequently, is not critical. Lines with orifice flanges should have the necessary straight runs before and after the orifice flanges as required in specifications or standards.

Locally mounted pressure and temperature indicators on exchanger nozzles, on the shell or process lines should be visible from the access aisles. Similarly gage glasses and level controllers on exchangers should be visible and associated valves accessible from this aisle. When arranging instrument connections on exchangers sufficient clearances should be left between flanges and exchanger supports; between instruments and adjacent piping. Insulation of piping and exchangers should also be taken into account. Care should be taken to give due consideration to internal details of heat exchangers when arranging instruments.

TUBE BUNDLE HANDLING

When doing maintenance work on an exchanger either the complete unit is removed, cleaned and repaired where such facilities are available. Or, only the tube bundle is removed for cleaning and repair; the shell is cleaned in place. In the first case all piping, in the second case only channel nozzle piping need be disconnected. The piping designer can help maintenance in three ways.

1. By designing and supporting piping so that no temporary support will be required when removing the channel and tube bundle; or at least temporary supports can easily be built.

2. By providing easily removable spool pieces, flanged elbows, break flanges, or short pipe runs to provide adequate clearances for tube removal equipment.

3. By leaving space and access around the exchanger as shown already in Figure 21.

The removal of tube bundles at grade is facilitated by hitching points in the front of exchangers. Chain or rope is fixed to the bundle and hitching point and a pulley transmits the necessary force and motion for removal. The hitching point can be at grade as shown on Figure 23, Sketch A. The distance between the

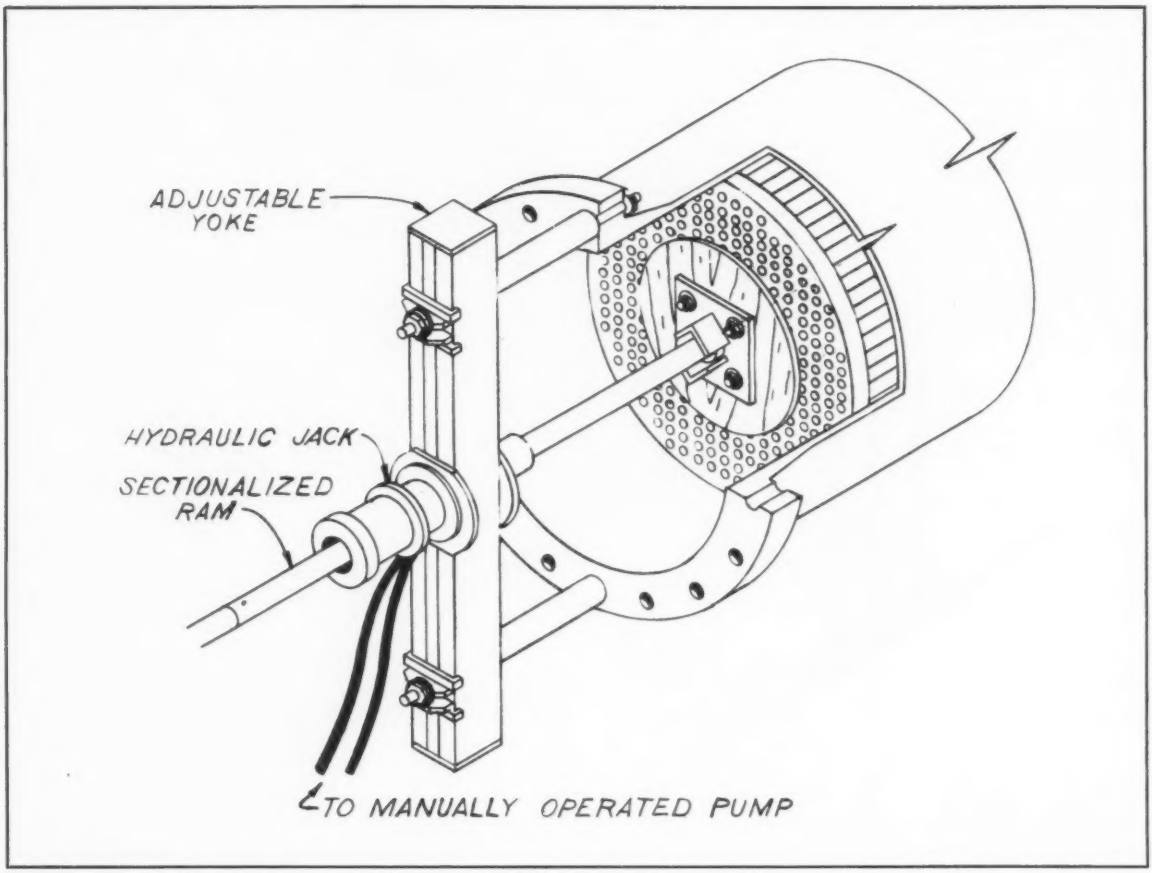


FIGURE 25—This hydraulic bundle puller can eliminate bundle handling steel.

front of exchanger and hitching point is about twice the bundle length.

A more positive pulling force can be exerted horizontally with hitching point in line with exchanger centerline. Existing structures in convenient positions can be used for rigging up pulling beam for bundle removal.

Figure 23, Sketch B shows trolley and pulling beams in a permanent structure over exchangers. This is usually arranged when required for single or stacked exchangers.

For handling many single or stacked exchangers at grade a travelling gantry can be provided. See Figure 24. The gantry consists of trolley beam, trolley and pulling beam on a structural frame which can be moved on rails along the front of exchangers.

A considerable saving can be achieved in capital outlay and maintenance with the hydraulic bundle remover shown on Figure 25. Using this equipment eliminates permanent trolley beams and structures, gantry cranes, walkways and pulling structure. In short no tube pulling provision need be provided for any exchanger in the plant. The yoke fits any diameter of shell and the sectionalized ram can push out any length of bundle with the hydraulic jack which can exert force up to 12,000 pounds. The same equipment can remove and replace the bundle.

The layout of exchangers and associated piping in a petrochemical plant is quite simple. However, it is hoped that this article has shown how many details are involved in designing this simple layout.

About the Author

Robert Kern studied mechanical engineering at the Royal Joseph Technical University, Budapest, Hungary, where he received his engineering degree in 1946. He left Hungary in 1948 and went to England where he joined Kellogg International Corp., London, to work in plant layout, piping design and design coordination. Kern has been in the United States since March, 1958.

How to Estimate Chemical Selling Price

Here's an empirical correlation for determining the approximate selling price of organic chemicals

Sidney Katell, Bureau of Mines, Morgantown, W. Va.
Liang-tsen Fan, Kansas State College, Manhattan

OF THE FACTORS that control the selling price or production cost of a new chemical, many have yet to be established. During the early stages of laboratory or pilot plant development, however, a rational approach to estimating the cost or selling price of organic chemicals may be possible, based on one of their physical or chemical characteristics. Specifically, the data to be presented will be based on the molecular weight.

This correlating equation might be useful for: (a) Making a preliminary estimate of the cost and market price of a chemical even before pilot plant data are available (however, more than one of its homologs would have to be currently being manufactured and marketed); (b) establishing a preliminary goal for developing a process to produce a new chemical; (c) presenting the cost or price change of a specific chemical within the framework of the homologous series; and (d) examining cost or price of a specific chemical with reference to other members of the series. Any considerable deviation from the correlation would reflect some abnormality, such as surplus or shortage of the chemical.

Assumptions used in making the correlation are:

1. The basic scheme for producing or synthesizing each member of an organic homologous series is similar.

2. A higher molecular weight of a chemical means a high weight or volume per molar quantity of the chemical and implies a more complex molecular structure. This, in turn, indicates the necessity of additional steps of labor and energy for producing a mole of chemical compared with other members of a series which have a lower molecular weight.

3. On the basis of the additional labor and energy requirements, a higher cost and price can be expected for the homolog of higher molecular weight.

4. More than one member of the homologous series is being commercially produced, and their cost and price structure have been available for some time.

The correlation between cost or price on a molar basis and molecular weight within a homologous series is postulated to be exponential: $P = A\ (m)^x$, where P is the cost or selling price in dollars per pound-mole, and m is the molecular weight. Both A and x are constants for any particular series. Based on the assumptions outlined previously, this equation can be used in estimating the cost or selling price of a new compound.

To illustrate this correlation, the selling prices per pound-mole are plotted in Figure 1 as a function of the corresponding molecular weight for the following homologous members of organic compounds:

1. Mono-, di-, and triethylene glycol
2. Ethyl, propyl, butyl, and amyl acetate
3. Methyl, ethyl, propyl, and butyl alcohol
4. Mono-, di-, and trichlorobenzene
5. Benzene, toluene, and xylene

The prices used represent average values for the period 1950 through 1957.[1] The deviations, found in Figure 1, do not exceed ± 10 percent and are considered in the normal range of a correlation of this type.

From Figure 1 the values of the constants in the postulated equation can be determined for the various series. The slope of the lines is equal to the value of x, and A is the intercept with the Y axis where m is equal to 1. The equations, then, can be written as follows:

Series	Equation
1. Ethylene glycol	$P = 0.029\ (m)^{1.37}$
2. Ethyl acetate	$P = 0.0023\ (m)^{1.87}$

3. Methyl alcohol $P = 0.00037\ (m)^{2.37}$
4. Chlorobenzene $P = 0.0037\ (m)^{1.69}$
5. Benzene $P = 0.191\ (m)^{0.69}$

Other homologous series could be evaluated in a similar manner, and the use of other physical properties such as boiling point or vapor pressure could be explored. Furthermore, the use of production costs in place of selling price may eliminate or, at least, minimize the deviation of ± 10 percent.

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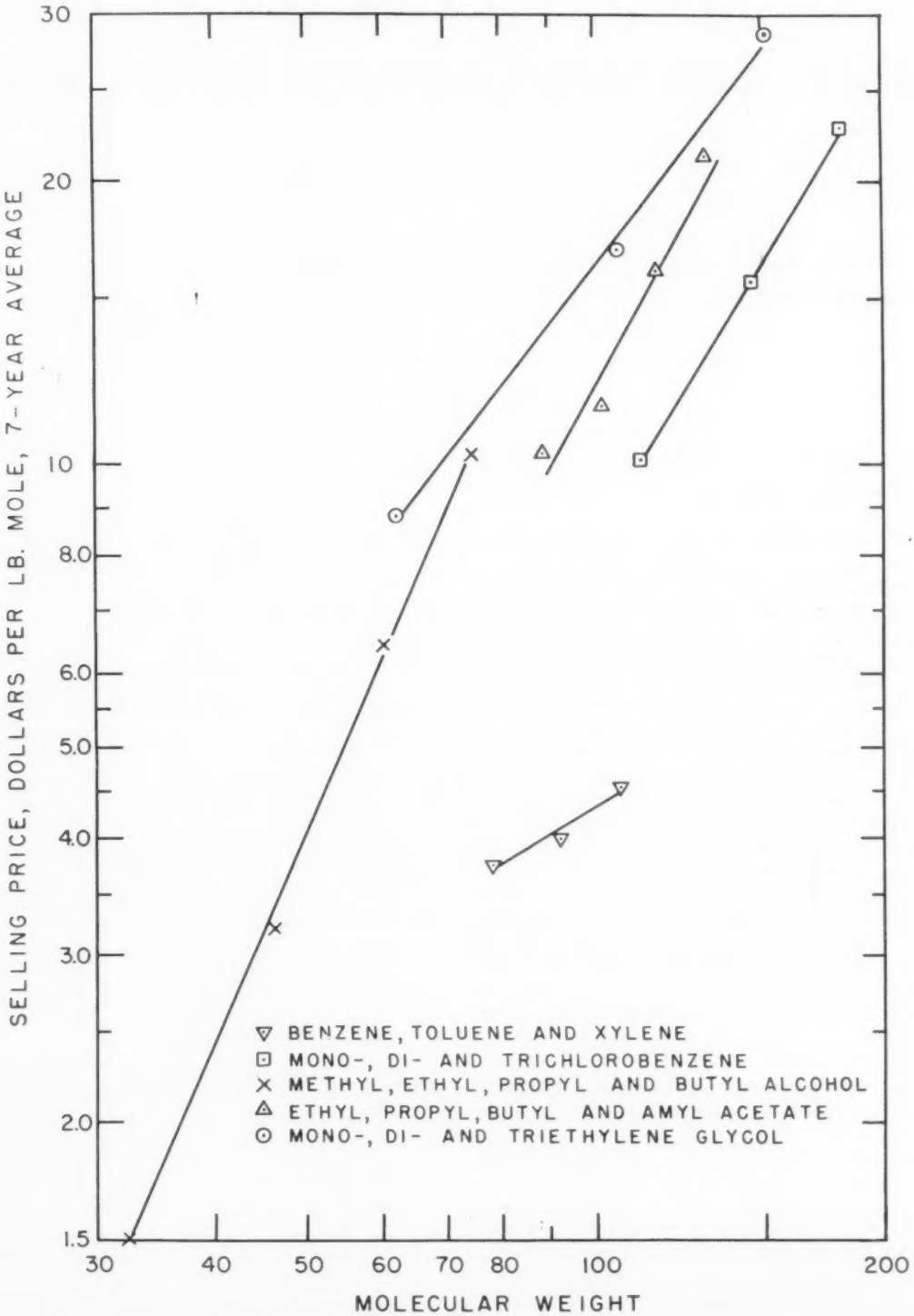

FIGURE 1—Shows how molecular weight affects selling price for five general types of chemicals.

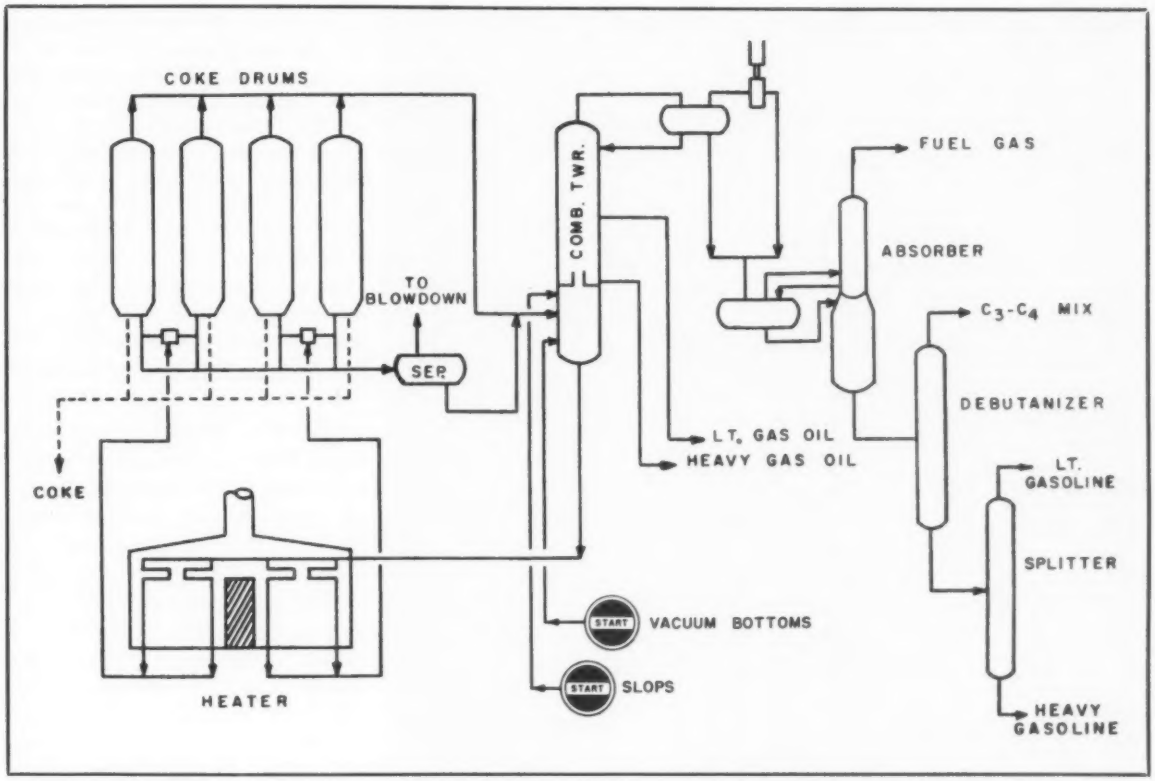

FIGURE 1—The delayed coker unit includes four coke drums and a complete vapor recovery system.

Coker Can Handle High Carbon Stock

Unlike most delayed cokers processing lighter feed stocks, American Oil's coker charges feed directly from the bottom of a combination crude tower. Here's an appraisal of the coker's operation

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IN JANUARY 1957, The American Oil Company placed a delayed coking unit onstream at their new Yorktown, Va., refinery. This unit is the newer of two delayed coking units now operating in The American Oil Company; the other being at El Dorado, Arkansas.[1] A third unit is under construction at Texas City, Texas.

Summary of Unit Operations. Operation of the Yorktown delayed coking unit, designed and constructed by the Lummus Company, has been exceptional. The unit operating factor for the first 20 months was 93.1 percent. Approximately 75 percent of the downtime was due to lack of feed stock and other general refinery problems. Eliminating these periods, would give an operating factor approaching 97 percent.

The first run was initiated on Jan. 30, 1957 charging Tia Juana medium resid and continued until July 6 of that year when the unit was taken offstream because of a lack of feed stock. Only minor maintenance was performed during this shutdown. Random tubes in the furnace were inspected and found to be clean. Inspection of the bottom of the combination tower revealed no coking or buildup of material on the tower screen.

The unit was then brought up on August 7 and it remained onstream until its scheduled shutdown for reconditioning on March 29, 1958. This run was continuous for 13 months except for a 63-hour period when the unit was placed on gas oil circulation because of a refinery fire and lack of feed.

During this first *scheduled* shutdown, the unit was thoroughly inspected and found to be in good condition. Inspection of the combination tower and coke drum piping showed little or no coke. Steam-air decoking of the furnace tubes was performed. Close monitoring of the furnace tube temperatures showed

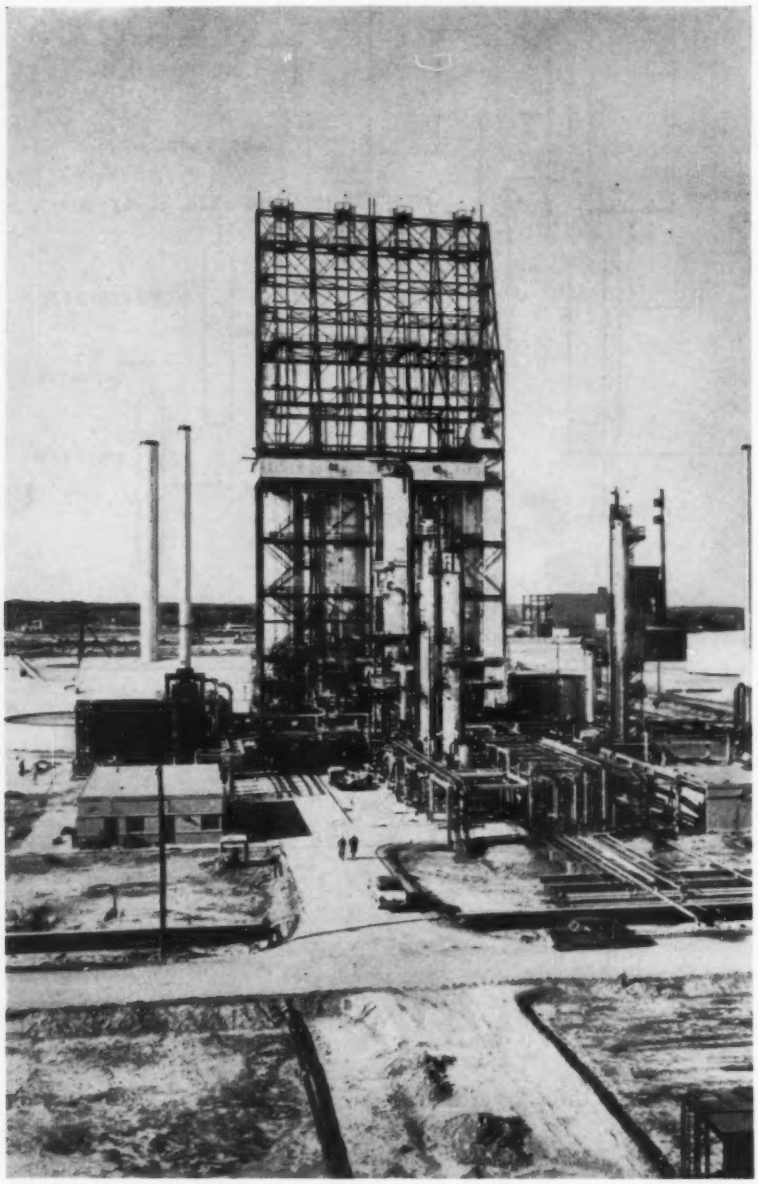

FIGURE 2—During the first scheduled shutdown, the unit was inspected and found to be in good condition.

that very little coke was burned during the decoking step. Subsequent tube inspection showed them to be clean.

The unit was placed onstream for Run #2 on April 6, 1958 and remained onstream for 8,722 hours until it was shutdown on April 4, 1959 for a routine turnaround. Conditions found were essentially the same as found during the previous turnaround.

Unit Design Features. Coking of the residuum from Tia Juana medium crude presented a considerable challenge to both American Oil and Lummus. Although the delayed coking process was almost 25 years old,[2] no one had previously commercially coked Tia Juana residuum nor had any commercial units coked a material containing as high a percent Conradson carbon (about 20-25 wt. %). Nevertheless, delayed coking promised specific advantages over visbreaking, and fluid coking with respect to gas oil quality and the grinding and burning characteristics of the coke.

Actual design work on the unit was started in June 1955; construction started in January 1956, and the unit was completed in December 1956.

The unit includes four coke drums with a complete vapor recovery system, and was designed to produce approximately 600 tons per day of coke from 9,200 barrels per stream day of 25 percent Tia Juana reduced crude (above 1,000° F end point gas oil). The process flow is shown in Figure 1. The design charge consisted mainly of hot (580° F) reduced crude brought directly from the crude unit, plus some from heated storage (225°-275° F). Pertinent properties of this primary feed stock are shown in Table 1.

Provision also was made in the design for charging as much as 10,000 barrels per stream day of a less highly reduced crude and for rerunning both light and heavy refinery slops.

Design product separation and recovery was based on the overall requirements of the refinery and its integrated operations. Coker products consist of gas oil for catalytic cracking and for further processing to No. 2 fuel oil, light gasoline for direct blending, heavy gasoline for reforming charge, C_3-C_4 for polymerization and LPG recovery, coke and fuel gas.

Unlike most delayed cokers processing lighter feed stocks, the Yorktown unit was designed to charge the fresh feed directly to the surge section in the bottom of the combi-

Table 1—Coker Feed Stock

Gravity, °API	6.1
Conradson Carbon, Weight Percent	25
Vanadium, PPM	300
Sulfur, Weight Percent	3.1

nation tower rather than over the baffle section. This change was made to prevent vaporization and/or mechanical carryover of the high vanadium content charge into heavy gas oil. Design operation was at a recycle ratio (furnace charge/fresh feed) of 1.15 with provision for running at 1.4.

The "heart" of the coking process, the furnace, is basically two heaters in one. Firing is done by ninety-six gas fired floor burners (arranged in 8 rows). The furnace is arranged in four parallel passes with each pass containing 46-4-inch OD tubes. The tube material is 6-8 percent chrome, ½ percent moly. Provision was made to inject steam at the entrance to the exposed roof tubes and/or the wall tubes. Design heat input to the oil was 57.7MBtu/H at an efficiency of 77 percent. The piping is so arranged that two coke drums and one side of the heater may be removed from service while the other drums and half the heater remain on stream. This design was adopted to make possible steam-air decoking the heater during operations to extend run length. This scheme has been employed following each scheduled turnaround and twice while the unit was on stream. The operation under these conditions was entirely satisfactory.

Four coke drums (17.5 ft. diameter by 75 ft., tangent to tangent) were provided in the system. These drums are arranged in pairs with a switch valve for each pair. Separate overhead lines recombine into a common line back to the combination tower. The coke drums are completely lined with 7/64-inch thick 11-13 percent chrome strips which eliminate the need for any corrosion allowance for drum thickness.

Table 2—Coke Drum Cycle

	Hours
Onstream filling with coke (Including 20 Min. switch)	24
Steaming Out	2
Water Cooling	3
Draining Water	1½
Idle Time	1½
Removing Heads	1
Hydraulic Decoking	5—6
Replacing Heads and Steam Testing	1
Heating Up	5—7
Idle Time	1—4
Total Cycle Time	48

FIGURE 3—Eliminating periods of insufficient feed, the coking unit gives an operating factor of about 97 percent.

Each coke drum operates on a 48-hour cycle; 24 hours on stream and 24 hours off. Thus, two drums are removed from service daily. A typical cycle is shown in Table 2.

Coke removal is hydraulic, using 2,400 psig water. A single pump is used for cutting water, but each drum is provided with a separate drill stem assembly. The hydraulic cutting system and procedure is essentially the same as that previously described for American's El Dorado coker.

As the coke is cut from the drum, it falls into a sluiceway from which it is dragged to the refinery coke pile. The water is pumped to a clarifier and the clear water sent to a tank for reuse. Coke fines from the clarifier are returned to the coke pile.

All of the coke produced at Yorktown is consumed at the new Virginia Electric Power Company generating station, located adjacent to the refinery. The coke is transported from the refinery intermediate storage area to the Virginia Electric Power Company's storage pile by a twin diesel powered self-loading scraper. This single 25 cubic yard scraper easily moves the coke, making the 0.5 mile round trip in approximately 10 minutes. This is the first application of using this

About the Authors

Meyer Webb

Donald B. Meyer is superintendant of technical services at the Yorktown refinery. Just prior to his assignment to Yorktown, Meyer was in New York coordinating process design for American Oil Co. with the constructors during the design of the refinery. He joined Amoco in 1948 following his graduation with a degree in chemical engineering from the University of Iowa. His experience includes both process design and technical service while located at Texas City in the Research and Development Department.

Jack C. Webb is unit foreman in the Operating Department for American Oil Co.'s Yorktown, Va., refinery. In addition to being in charge of the delayed coking unit, Webb is responsible for the refinery's utilities and gas treating facilities. He has been with Amoco since graduation in 1948 from Georgia Tech with a degree in industrial engineering and is a registered professional engineer in Texas. Prior to his transfer to Yorktown in 1956, Webb worked in the Engineering, Mechanical and Operating Departments at Texas City.

type equipment to handle coke, although it has previously been used for coal transport.

Yields and Product Inspection. The fresh coker feed has been somewhat lighter than design throughout most of operations. However, design feed stock was run successfully for several months immediately after startup. The unit has operated at fresh feed rates of 12,500-13,000 barrels per stream day for sustained periods with maximum rates of 14,000 barrels per day, or 140 percent of designed capacity, attained on occasion. Operation has been primarily at throughput ratios of 1.1 - 1.2. During voluntary reduction of foreign crude imports, the unit successfully processed a variety of domestic and foreign reduced crudes such as Baxterville, Hawkins, Brazilian (Bahia) and Boscan.

A comparison of design yields with actual yields is shown in Table 3. Notable in this comparison of yields is that actual yields of gasoline and coke are lower than design. Almost all of the increment between actual and design yields for these products is made up by increased yield of heavy gas oil (fluid catalytic cracking charge). The actual heavy gas oil yield (above 650° F) is essentially equal to the predicted yield from fluid coking of the same stock.

TABLE 3—PRODUCT YIELD COMPARISON

	DESIGN			ACTUAL		
	B/SD	Weight Percent	Volume Percent	B/SD	Weight Percent	Volume Percent
Charge:						
Outside Vapor	....	5.6	8.8	....	0.5	1.0
Outside Liquid	....	....	....	460	2.1	3.9
Light Slop	880	6.0	7.4	880	5.8	7.5
Heavy Slop	300	2.4	2.5	....	....	....
Vacuum Bottoms	9,660	86.0	81.3	10,340	91.6	87.6
Products:						
Fuel Gas	....	4.4	....	....	3.7	....
Gas to FCCU	....	4.1	....	....	2.9	....
Liquid to FCCU	550	2.7	4.6	500	2.4	4.2
Light Gasoline	1,430	8.6	12.0	1,490	8.8	12.6
Heavy Gasoline	2,260	15.7	19.0	1,570	10.6	13.3
Light Gas Oil	2,350	17.7	19.8	2,450	18.1	20.7
Heavy Gas Oil	1,990	16.2	16.8	2,690	21.6	22.8
Heavy Slop	....	....	....	280	2.2	2.3
Coke (T/D)	(610)	30.6	....	(598)	29.7	....
		100.0	72.2		100.0	75.9

TABLE 4—ANALYSES OF PRODUCT AND CHARGE STREAMS

	UNIT CHARGE			UNIT PRODUCTS				
	Vacuum BTMS	Light Slop	Furnace Charge	Light Gaso.	Heavy Gaso.	Light Gas Oil	Heavy Gas Oil	Coke
Gravity, °API	7.4	55.9	9.5	76.9	49.9	34.5	22.3	....
RVP, Psi	....	....	....	10.5	....	....	....	....
ASTM Dist., °F.								
IBP	....	....	....	97	243	348	330	....
10	....	....	....	118	264	431	597	....
30	....	....	....	128	282	466	664	....
50	....	....	....	140	302	499	760*	....
70	....	....	....	158	326	543	.....	....
90	....	....	....	183	360	605	.....	....
FBP	....	....	....	201	396	650	.....	....
RSH, Weight Percent	....	....	....	0.086	....	....	....	....
Sulfur, Weight Percent	2.76	0.23	....	0.13	0.25	1.15	1.57	4.27
Ramsbottom Carbon, Weight Percent	19.6	....	17.4	.....	.....	0.03	0.30	....
Ash, Weight Percent	....	....	....	.....	.....	.....	.....	0.99
VCM, Weight Percent	....	....	....	.....	.....	.....	.....	10.15
Metals, ppm								
V	....	....	....	.....	.....	Nil	0.26	900
Ni	....	....	....	.....	.....	0.02	0.05	100

Typical liquid product inspections when charging 30 percent reduced Tia Juana crude are shown in Table 4. Of considerable interest is that the metals content of the heavy coker gas oil (at 0.3 weight percent Ramsbottom carbon) is approximately equal to the metals in the virgin heavy vacuum gas oil from the same crude at 0.2 weight percent Ramsbottom carbon. The light coker gasoline has been successfully treated as a 50-50 blend with straight run gasoline in a conventional copper chloride treating unit. Heavy gasoline, after desulfurization, has been charged successfully to a reformer operating at high severity.

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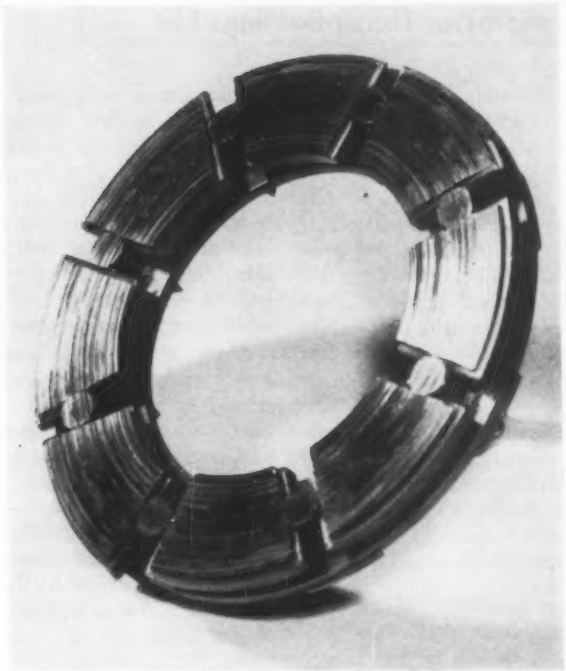

Why Compressor Thrust Bearings Fail

Trouble shooting clues and typical thrust load calculations will help you find and eliminate the cause of thrust bearing failures

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WHEN THE THRUST bearing on a key piece of equipment fails, a costly shutdown follows and everyone from the plant manager on down is vitally concerned. Repairs proceed as quickly as possible. However, the best efforts of everyone involved will be wasted in a repeat failure unless the real cause is found and corrected.

Here is a stepwise procedure for doing the "detective work" on thrust bearing failures. Although most of this information is based on experience with centrifugal compressors, it applies generally to other machinery having tilting shoe or tapered land thrust bearings.

Avoiding Trouble. Most failures can be avoided if certain precautions are taken. By making the following routine checks prior to start-up, the possibility of a thrust failure is considerably reduced:

- Check, adjust and record thrust bearing end play within manufacturer's recommended tolerance.
- Check run out on both sides of the thrust collar. Anything over .0005 inch should be corrected.
- Blue the thrust collar to determine that all shoes are being uniformly contacted.
- The lubrication system must be absolutely clean. Equipment should be inspected and after fabrication and fit-up, all piping should be cleaned and coated with preservative. Chemical cleaning (pickling) is the most positive means for a good job. The cost is very reasonable and numerous firms that specialize in this work are available in most localities. Before operation, the system should be flushed with hot oil by circulating and filtering until absolutely clean.
- Check and record cold alignment on machinery. The manufacturer should be consulted to establish the tolerances for the cold setting.
- All equipment, safety devices, trips and instrumentation connected with the lubrication system should be checked and adjusted for proper operation.

Another point to be considered here is the damage to costly and hard to replace internals that occur along with a thrust bearing failure. If precautions are taken to open all clearances adjacent to the rotating assembly in the direction of proba-

ble thrust failure, damage can be minimized or even avoided. Babbitt thickness of the bearing often determines total movement of the rotor during a failure. Thus, if the babbitt thickness is 1/16 inch, internal clearance from the normal running position should be at least two times this amount and more if possible. Total rotor end play and running position of the rotor should be checked and recorded.

After a Failure. Once a thrust failure has occurred, lay out a careful plan for investigation. In order to proceed methodically, the possible causes of failure must be considered and are listed as follows:

Improper Assembly. If precautions are taken as previously outlined, trouble in this respect is improbable.

Dirt, Sludge or Corrosion Products. Even though extreme care is taken, it is impossible to eliminate this as a factor.

Liquid Slugs. This is a cause that often gets the blame but is difficult to prove or verify. Liquid slugs can occur even though knockout drums are installed in the suction lines.

Improper Lubrication. Lubrication is a science in itself, and it is easy to become involved in unnecessary detail not directly related to the problem.

Electrostatic Shaft Voltage. A phenomena which slowly destroys the hydrodynamic operation and roughens the surface of a thrust bearing resulting in failure.

Excessive Thrust Load. Although liquid slugs may also be included in this category, the discussion here is limited to developments in the field during normal operation and design errors.

Only careful inspection will show which of the possibilities caused the failure. Often, good evidence is destroyed by proceeding too quickly with the teardown or lack of concern on the part of craftsmen. Personnel in charge of the investigation should always be present when the machinery is first opened. Photographs can be used to great advantage in retaining a record of the appearance of the machinery as it is opened. Good notes of all significant findings and records of dimensional checks or indicator readings will be helpful for future reference when deciding on repairs.

Early in the investigation, total end play of the rotating assembly should be checked. This will indicate the extent of the thrust failure and internal damage. If end play is less than the minimum clearance between the normal operating position of the rotor and stationary internals, it will not be necessary to open the case unless further investigation is required to find the cause of the failure.

Trouble-Shooting. Considering each possibility separately, look for these clues to point up the trouble.

Improper Assembly. Unfortunately, when a thrust failure occurs, the bearing itself is usually totally wrecked. This makes it practically impossible to check and compare clearances or dimensional checks to original drawings and recommendations. But there are other possibilities that can be found. Look for small parts, retaining or locating members and leveling assemblies that have worked loose or have been improperly installed. On tilting shoe bearings, fretting under load carrying buttons is an indication of a misaligned thrust collar. Axial alignment of the thrust collar can be checked on the undamaged side using indicators.

Dirt, Sludge or Corrosion Products. Since there is always a possibility of getting dirt, sludge or corrosion products into an oil system, it is a very probable cause of bearing failure. However, repeated failures have occurred because engineers and mechanics have too quickly laid the blame on foreign material. All other causes should be investigated before accepting this as a real cause.

Examination and analysis of sediment in bearing housings, tank bottoms and strainers will show the extent of fouling and the possible source of material. Still, a great deal of knowledge about the foreign matter only leads to methods for eliminating the fouling but does not prove that it was the cause of the failure. Foreign material in the failed bearing is not a good clue to a failure in this respect since much of the deposit is the result of the failure. A better indication is possible by examination of other bearings in the same system which have not failed. If all the bearings are generally scored and have excessive quantities of foreign material imbedded in the babbitt, a fouled system is certainly evident.

Piping connections should be broken and inspected for loose granular material and scale. If the piping system is dirty, chemical cleaning is recommended. Other methods such as blowing with steam, sandblasting or pulling cleaning rags through the sections of piping are not as reliable and may actually do more harm than good.

There are several steps that can be taken to minimize the possibility of a failure caused by foreign material and prevent accumulations in the system. These are:

- Coat all bearing housings and oil collecting chambers with a good crankcase sealing compound.

- Install temperature controllers on oil supply to minimize condensation in bearing housings and tanks.

- Utilize a portable oil purifier and periodically connect to the system to clean the oil, even if oil is filtered.

- If oil tanks are exposed to weather or cold air, insulate and weather-protect covers to minimize condensation. Further, a small blower to vent humid air from the reservoir can be installed. Another more elaborate approach is to install an inert gas blanket system.

- Check oil samples periodically for all types of contamination. In comparing results of used oil analyses, the percentage of pentane insolubles gives a good indication of the amount of rust, dirt, metal particles and sludge forming materials present in the used oil.

A laboratory analysis once a month is recommended. Inhibitor strength should also be checked

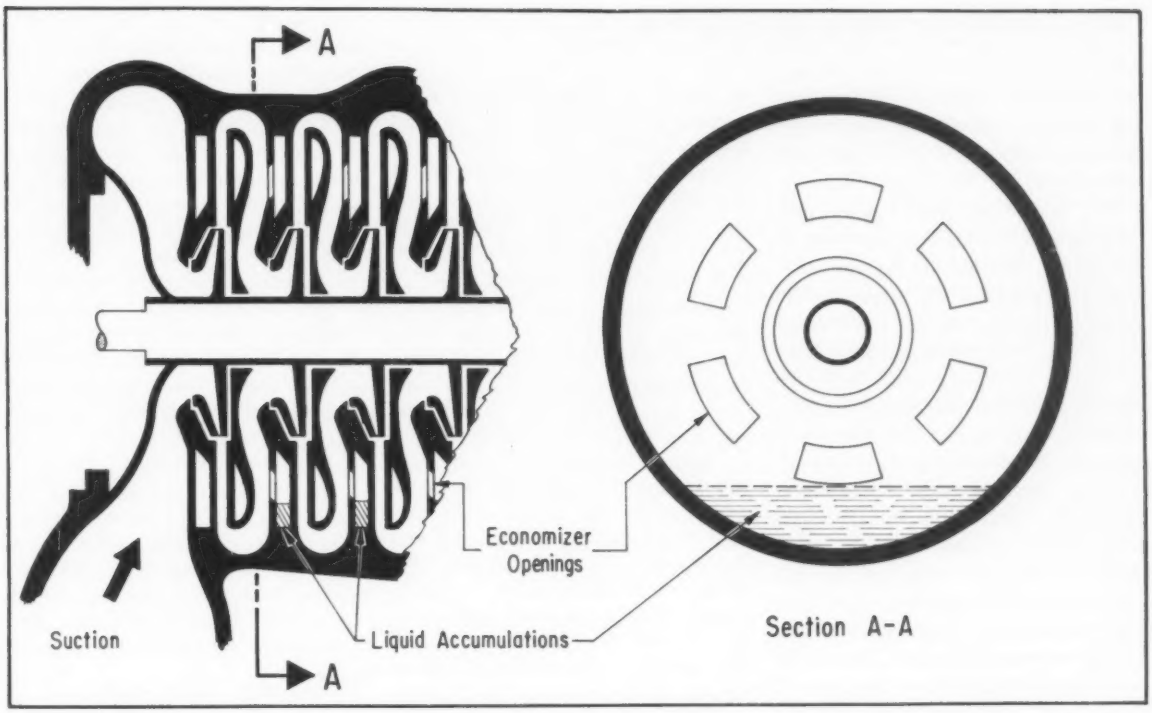

FIGURE 1—Cross section of compressor shows liquid accumulations in the diaphragm openings.

where required. Operators should make daily visual checks. Samples should always be taken while the oil is hot and in circulation, in order to obtain a representative sample.

Liquid Slugs. It is surprising to note that there are many possible sources from which a compressor might receive a slug of liquid. The first one to be considered is carryover from a knockout drum in the suction line to the machine. Most installations include high level alarms and shut down devices to protect against this possibility. However, there are many circumstances where this equipment might be inoperative while the machine is in operation. Such instrumentation should always be checked after a failure and operators should be questioned concerning the level in knockout drums at the time of failure.

Another source of liquid slugs is in trapped sections of suction lines. Even straight sections of piping can collect several gallons of liquid if they are not exactly horizontal or sloped continuously in the same direction. All piping should be rechecked carefully for pockets formed by improper slopes and arrangements.

A third possibility is in the compressor itself. Some manufacturers use standard patterns with economizer openings for casting diaphragms for each size machine. Thus, all machine diaphragms will have economizer openings whether required or not. Figure 1 clearly illustrates where liquid can collect in the diaphragm and be slugged into the machine. Normally, liquid will not collect in these void spaces because most condensate from the compressed gas stream will vaporize during operation. However, in those machines where condensate might collect or where liquid injection is used to prevent fouling of internals by a dirty gas, precautions should be taken. If the manufacturer is properly informed, special modifications to patterns can be made to close the openings. If the problem arises after construction of the machine, void spaces up to the level where liquid will collect can be filled with a suitable inert material.

Finally, improper operation of seals or labyrinths can permit lubricating or seal oil to enter the case in sufficient quantity to cause a failure.

Knowing where liquid slugs accumulate, the question is how to determine that a liquid slug occurred and where the liquid came from. Usually, the operator can be depended on to accurately describe the failure and confirm the occurrence of a liquid carryover. Close inspection at the machine will verify other possibilities.

When the case is depressurized, all liquid drained out of case should be collected, measured and analyzed in the laboratory. Excessive quantity of liquid is an indication of liquid slugging and a comparison of its analysis to that of lubricating oil, seal oil, injection oil and gas condensate will often indicate the source of the liquid. Also, when the case is opened, the machine will normally be wet with liquid if the

TABLE 1—Comparison of New and Used Oil to Manufacturer's Recommendations

Oil Properties	Mfgr's. Recommendation	New Oil	Used Oil
Viscosity, 100° F. SSU	150± 10	149.8	148.1
Diel. Min. KV	25	.....	.....
Pour Point, Max. °F.	20	.....	.....
Flash Point, Min. °F.	350	410	405
Neut. Max.	.20	.06	.06
Gravity, °API	31	30.7	29.8

machine was slugged. Void spaces can be syphoned and a comparative analysis of this liquid will indicate the source.

If analysis of the liquid indicates that lubricating or seal oil is the source, this can be further verified by checking oil consumption prior to the failure. Excessive consumption, if not collected in a sour oil tank, probably leaked into the machine through bad O-rings, labyrinths or sealing surfaces. Close inspection of all sealing devices and mating surfaces should indicate where the leak occurred. In addition, seal reference pressure taps should always be taken off downstream of any devices such as strainers, valves, etc., in order to avoid excessive seal oil pressure. High seal oil pressure might cause leakage.

By carefully examining the evidence and finding the source of the liquid, the possibility of a repeated failure due to liquid slugging is materially reduced.

Improper Lubrication. Unless the particular compressor or bearing design is a new development, the manufacturer's recommendations can usually be depended on for specification of the proper lubricant. Dirt, sludge, water and corrosion products as affecting lubrication have previously been discussed. Thus, further investigation in this field should be limited to verification of the use of proper lubricating oil, contamination and adequate flow of oil.

Installation and instruction manuals should be checked to determine the properties and specifications of the required oil. If there is more than one piece of machinery served by a common oil system, specifications for lubricating oil should be in agreement for all components. Check delivery records to determine that the proper lubricant was furnished to the system. Further, obtain a representative sample of the oil and make a comparison of the laboratory analysis of used and new oil. Table 1 shows a typical comparison of used and new oil and the properties that should be checked. If all of the properties of the oil are comparable as in the case shown in Table 1, and the oil is clean and free of water, the oil is probably satisfactory.

Contamination can occur by (1) absorbing lighter hydrocarbons from the gas being pumped, (2) water condensation in tanks or chambers in the system and (3) sludge, dirt and corrosion products collecting in the system. Viscosity and flash point will change considerably if oil is contaminated by lighter hydrocarbons. Close inspection of the oil and the system will show whether the oil is contaminated with water or sludge. The presence of sulfur can be detected by exposing lead acetate soaked paper to the oil. When the oil in a system is badly contaminated, dump the oil, clean and flush the system and fill with fresh oil.

Even though the right kind of oil is used in the system, the bearings may fail because of an insufficient flow of oil. Plugged supply and return lines, improper balance and control of system, inadequate pumping capacity, etc., can all result in a failure caused by improper lubrication. Enough information is usually available from the manufacturer to check the hydraulics of the system. It is relatively easy to check the supply of oil to individual bearings by measuring flow into a container for a short period.

If the required quantity of oil to be supplied to the thrust bearing is unknown, it can be calculated. Most manufacturers probably have an individual approach to the problem but here is a method which will assure an adequate supply of oil. Obtain the total horsepower loss in the bearing either from manufacturer's data or by calculation.[1] Assume 85 to 90 percent of this loss on the loaded shoes of the thrust bearing and provide twice the quantity of oil required for heat removal of this horsepower loss.

Once it has been determined that the proper oil is in the system, that the oil is not contaminated and there is an adequate supply, improper lubrication failures can be considered improbable and other possibilities should be investigated.

Electrostatic Shaft Voltage. Although this phenomenon has been a problem in many phases of engineering, it is surprising that very few engineers consider the problem as related to thrust bearing failures. However, there have been several articles written on the subject and a review of this information will result in a quick understanding of the problem.[2]

Briefly, these factors will indicate the possibility of electrostatic shaft voltage as a cause of thrust bearing failures. First, shaft voltage must be generated by the equip-

TABLE 2—Typical Compressor Thrust Bearing Calculation Summary, Impeller Thrust

STAGE	1	2	3	4	5	6	7	8
A. O.D. Impeller Eye, In.	14	14	14	13	13	13	12	12
B. O.D. Shaft Sleeves, In.	8¼	8¼	8¼	8¼	8¼	8¼	8¼	8¼
C. Eye Area, Sq. In.	153.6	153.6	153.6	132.6	132.6	132.6	113.0	113.0
D. Shaft Sleeve Area, Sq. In.	53.6	53.6	53.6	53.6	53.6	53.6	53.6	53.6
E. Net Thrust Area, Sq. In.	100	100	100	79	79	79	59.4	59.4
F. Discharge Pressure, psi	153	187	226	271	314	370	435	506
G. Intake Pressure, psi	124	153	187	226	267	314	370	435
H. △P per Stage, psi	29	34	39	45	47	56	65	71
I. .6△P, psi	17.4	20.4	23.4	27	28.2	33.6	39	42.5
J. Thrust-lbs. (E x I)	1740	2040	2340	2140	2230	2660	2320	2520

Total Thrust 17,990 (Total of Item J)

BALANCE PISTON THRUST

High Side Balance Piston Pressure, psi	477.5
Low Side Balance Piston Pressure, psi	124
Balance Piston Differential Pressure, psi	353.5
O.D. Balance Piston, In.	11¼
Balance Piston Area, Sq. In.	99.4
O.D. Shaft Sleeve, In.	8¼
Shaft Sleeve Area, Sq. In.	53.6
Balance Piston Net Area, Sq. In.	45.8

Balance Piston Thrust = Pressure Differential x Net Area
= 353.5 x 45.8 = 16,200 lbs.

Unbalanced Force = Impeller Thrust–Balance Piston Thrust
= 17,990—16,200 = 1790 lbs.

Thrust Bearing Area = 12.2 sq. in.

Thrust Bearing Load = Unbalanced Force/Thrust Bearing Area
= 1790/12.2 = 146.7 psi.

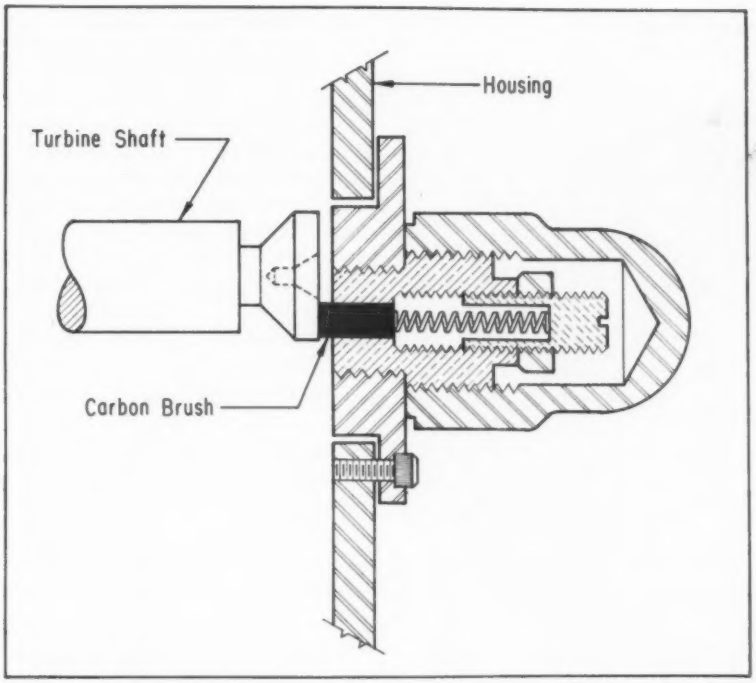

FIGURE 2—Grounding device on the end of a turbine shaft uses a carbon brush.

ment (i.e., the brushing effect of steam on turbine blading) as would be possible if a wet gas is flowing through a compressor or a condensing steam turbine is being used for the driver. The best way to determine the presence of electrostatic shaft voltage is to measure it when the machine is at full load using a 20,000 ohm per volt voltmeter from shaft to ground. Anything above five volts is generally accepted to be harmful and steps should be taken to reduce or eliminate this condition.

In many applications, even though shaft voltage is generated, it bleeds off through contact surfaces such as carbon seals, shaft-driven lube oil pumps, etc., to ground. However, if these contact surfaces become nonconductors due to wear or buildup of deposits then the generated voltage seeks another path to ground. This path is usually established at the thinnest oil film on one of the bearings and arcing occurs through the oil film. The electric arcs melt out numerous pits, mostly from the babbit metal. In addition, a breakdown of minute particles of oil occurs, and this lays down as a thin deposit of carbonaceous material on the surface of the bearing. This deposit destroys the hydrodynamic performance of the bearing shoes and is characterized by a slow increase in shoe surface temperatures. This type of damage can also be detected by inspection of bearing babbitt surfaces with a microscope after the deposit has been cleaned off. With 25X magnification, the surface of the bearing appears rough and pitted with thousands of little craters in the loaded area of the shoe. It is obvious that in the event of a complete failure all this evidence is destroyed. Therefore, thrust shoes should always be inspected during routine maintenance and overhaul to see if damage of this type is in progress.

Since it is impossible to eliminate the voltage at the source, a simple solution to the problem is to install a permanent ground. Grounding can be accomplished with carbon brushes, metallic shoes, mercury baths, water seals, etc. Figure 2 is an example of a carbon brush ground installed on the end of a turbine shaft.

Excessive Thrust Load. If no other cause for a thrust bearing failure can be found, then look at the thrust load. An excessive load can be the result of developments in the field after normal operation or original design errors in thrust calculations.

Some field developments include transmission of a load through the coupling from an adjacent machine, build-up of dirt or foreign matter internally to cause an axial displacement of the rotor and plugging of the balance line decreasing balance piston affect. All of these troubles are easily recognized and traced by inspection. Design errors, on the other hand, are more difficult to find.

A typical thrust bearing calculation summary is presented in Table 2 along with calculations of balance piston thrust and the thrust bearing load. Normal design bearing loads are in a range up to 150 psi, although some manufacturers indicate many bearings are capable of safely carrying 400 psi or more. In the example, if performance in the field conforms to empirical data, the ΔP developed per stage would be correct. And if the .6 thrust factor assumed was adequate, the thrust bearing would easily carry the load.

But suppose that the shaft diameter was reduced one inch between the sixth and seventh stage. If this were taken into account

Area of Shoulder $\times \Delta P$ = Additive Impeller Thrust.

$12.3 \times (409—124) = 4740$ lbs.

the impeller thrust would be increased 4740 lbs. With no other changes, this results in an excessive thrust bearing load of 535 psi. So watch for shoulders on the shaft and unaccounted-for pressure differentials.

Further, the thrust factor assumed initially may be inadequate. Thrust factor is an empirical number covering many factors such as wheel geometry, gas properties and labyrinth leakage. Values range generally from 0.6 to 1.0. Now suppose in the example a more accurate choice for thrust factor had been 0.8. The total thrust then is 23,960 lbs. and an excessive thrust bearing load of 636 psi is the result.

Once it is realized that the thrust factor is questionable, it is difficult to assume a reliable second choice.

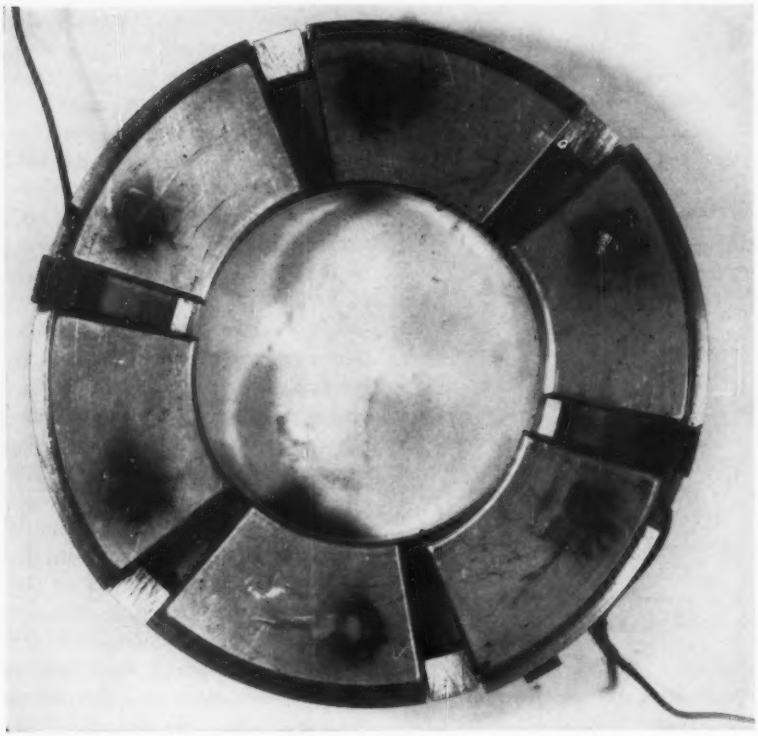

FIGURE 3—A compressor thrust bearing showing appearance prior to complete failure caused by excessive load.

The solution to an excessive thrust load is usually a larger balance piston. In order to avoid a trial and error series of balance pistons, it is possible to measure actual bearing load using strain gages. Knowing the actual load, an accurate balance piston size can be determined.

Because the design of a device to measure thrust is special for each machine or thrust bearing design, the manufacturer must usually be depended on to work out the details and furnish the proper equipment. There is some risk involved in this approach since the machine must be operated for a few hours under excessive load for data procurement. If previous failures occurred after several days operation, a run of several hours for test purposes can be considered a good risk.

Evidence of excessive thrust load can also be found by inspection of the loaded side of a thrust bearing prior to failure. Opportunity for such inspection is difficult, but if load tests are performed as previously described, shoes can be closely inspected after a few hours operation.

Figure 3 shows a bearing that was operated for 120 hours at an average load of 590 psi. The load was measured utilizing strain gages behind the loaded thrust shoes. There is a distribution of pressure across the face of a thrust bearing shoe, the highest pressure occuring at the black area in Figure 3. Thus, in this case, there were pressures well above and below the average of 590 psi. It is reasoned that under high pressure, the resultant thin oil film and localized excessive temperature breaks down the oil and causes the laydown of carbonaceous material. The extent of laydown increases until ultimate failure. The appearance of the blackened area is similar to that caused by electrostatic arcs, confusing the analysis.

A further indication of excessive load is plastic flow of the babbit face out and over the edges of the shoe with resultant thinning of the babbitt metal. It is probable that this is a more advanced stage of failure than that illustrated in Figure 3.

Causes of thrust bearing failures can be methodically tracked down. In order to insure a reliable repair job and avoid further problems, a detailed investigation to find a definite cause for the failure is required. There are undoubtedly other causes of failures which are not mentioned in this article. Individual experience and ingenuity will disclose these possibilities and lead to further knowledge about failures. Additional research is required to more accurately predict thrust load and establish maximum loads at which oil breakdown occurs.

ACKNOWLEDGMENT

The author wishes to express his appreciation to the Mobil Oil Company for the opportunity to publish this article. The help of the many people who assisted in the work leading to the publication of this article is also sincerely appreciated.

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About the Author

M. R. Noack is a project design supervisor for Mobil Oil Co., Beaumont, Texas. He supervises and coordinates mechanical design for all major projects involving new process units or alterations and additions to existing facilities at the Beaumont refinery. Holder of a B.S. degree in mechanical engineering from The University of Texas, he has been with Mobil for 10 years in all phases of project engineering. Noack also has experience in startups of refinery-type process units, air-conditioning design engineering, and naval architecture. He is a registered professional engineer in Texas.

FIGURE 1—A huge mound of dirt was piled on the tank site to pre-load the foundation for Tank No. 103.

Cut Foundation Costs for New Tanks

For a new storage tank, a piled foundation can often cost as much as the tank itself. But here's a method which gets away from pilings and reduces the cost of storage facilities

E. T. DiCorcia
Esso Standard Oil Company
Bayonne, N. J.

A MAJOR PORTION of a refinery's land area is occupied by storage tanks of all sizes—containing crude and finished products. What to do when this land is not strong enough to support the weight of a full tank is a long standing and costly problem in refinery construction.

At Esso Standard's Bayonne refinery where poor soils are a major problem, engineers have reduced the cost of tank foundations built during a recent replacement program in the following ways:

• In all areas where new tanks were to be built, an intensive soil investigation and foundation study were made to accurately evaluate the strength of the natural soils. Wherever possible, tanks were built directly on the surface of the ground without any special foundation treatment. Newly completed tanks were carefully water tested and the piping was not connected until all settling under the water load had stopped.

• In areas where the soil investigation indicated excessive settling would occur under a full tank load, and where the weak soils were too deep to be easily removed, the ground surface was pre-loaded with an earthen surcharge until the soils had gained sufficient strength to support the weight of a full tank.

• In areas where the weak soils were located close to the surface of the ground, the poor material was removed and replaced with sand and gravel. The tank was then built on top of this artificial surface. These methods gave satisfactory foundations costing much less than the

FIGURE 2—Completed pre-load embankments for Tanks 17 and 18 are shown here.

piled foundations that would otherwise have been built.

NEW TANK FOUNDATIONS ARE TRIED

Esso Standard Oil Company's Bayonne Refinery is located on a filled-in area which projects into the New York Harbor. The refinery's deep water piers are ideal for discharging the largest tankers. The land, however, is a combination of man-made fill lying over a soft organic mud and is too weak to support any major structure without serious settlement problems.

The upper fill layer, consisting mainly of cinders, ashes, and rubble, is in a relatively loose state of compaction. It is a source of rapid, uneven settlement under load.

Beneath the fill is the original waterfront which was quite flat and broadly traversed by tide water. Fine sand, silt, and clay sediments with entrained organic matter from the harbor are part of the second layer. Also this organic mud once supported a dense growth of weeds. The fill over the marsh (starting more than 50 years ago) caused the vegetation to decay and to form what is today a composite layer of organic silt, clay, and peat (root mat). This organic layer is very soft and will compress gradually but markedly under load.

Beneath the organic stratum there are two layers of dense, hard glacial soils. Triassic rock (Stockton formation) is encountered at about 100 feet below grade.

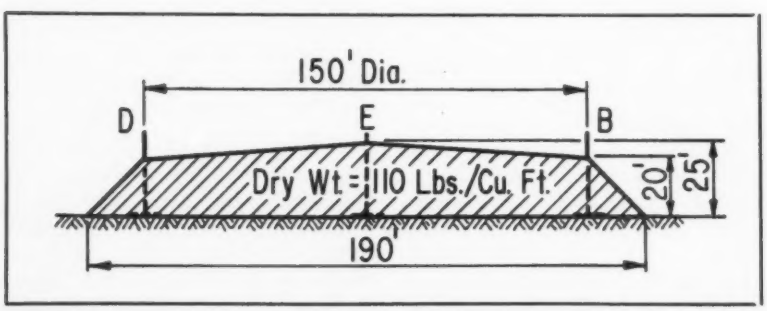


FIGURE 3—Here is the way the pre-load fill was used at the site of Tank No. 104.

In the past, the Bayonne refinery prepared foundations for all major structures by driving steel or timber piles through the upper two strata to reach a firm bearing in the hard, dense, glacial soils below. The piles were usually capped with a reinforced concrete platform and the final structure built on top of this.

This type of foundation construction is safe, straightforward, and is fairly economical for structures of small base area (such as towers, stacks, etc.). However, piled foundations have proven very costly for large-diameter storage tanks. On an average, the cost of a piled tank foundation is approximately equal to the cost of the tank itself. Typical construction costs in the Bayonne area are shown in Table 1.

The piles are creosote treated 30 feet long with 12-inch minimum butts and 8-inch minimum tips and have a safe load bearing capacity of 20 tons. The reinforced concrete is rated at 3,000 psi minimum compressive strength.

To reduce the investment required for new tank foundations, soil conditions at the site of each new storage tank were studied in great detail. Soil borings were made, and subsurface soil samples recovered for examination and laboratory testing by specialists in the field of soil mechanics and foundation engineering. Thus the refinery engineers, by working with competent soils consultants, were able to obtain reliable information on expected soil behavior in each case. The results of these studies revealed the opportunities and limitations for making cost savings. Because of their importance, a more detailed discussion of the soil investigations is included at the end of this article.

Preliminary soil investigations made for two new 44,000-barrel floating roof tanks (No. 17 and 18) and for three new 150,000-barrel cone roof tanks (No. 100, 103, and 104)

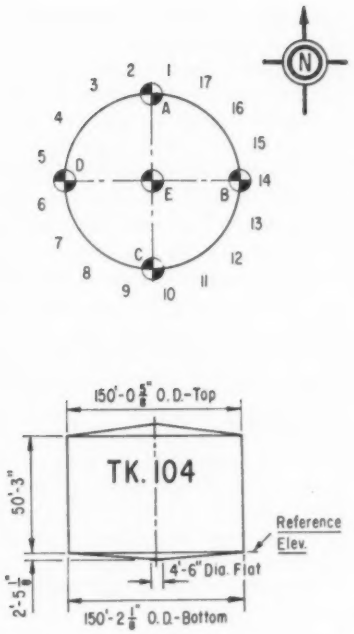


FIGURE 4—Observation points were established to use in measuring the amount of ground settlement. The lettered points were used to follow the amount of settlement during pre-loading and the numbered points were used to study the settlement of the finished tank.

showed that excessive and uneven settlements would occur under these tanks if they were built on a soil supported foundation. Since piled foundations for these tanks would have cost well over a half-million dollars, the refinery engineers had a big incentive to find a cheaper alternate to piling. They looked at three general solutions to the weak soil problem:

- Bypass the weak soils as with piles.
- Stabilize the weak soils in place by pre-loading, chemical injection, etc.
- Remove the weak soils and replace with suitable material.

In this case, due to the relative costs involved and the nature of the soil profile, the pre-load alternate looked best.

THE PRE-LOAD METHOD SAVES MONEY

The pre-load method consists of loading the foundation site with an inexpensive source of weight (usually earth fill) to consolidate the soils to a point where they will be strong enough to support a new structure with very little further settlement. The preliminary soil reports, for the sites of the five tanks mentioned, contained no information obviously unfavorable for the success of the pre-load method, but further investigation was needed to explore two major unknowns:

- How much time is required for full consolidation to take place?
- What is the magnitude and distribution of surface subsidence that will occur during and after pre-loading?

Laboratory tests were made on undisturbed samples of the various soils recovered from earth borings. These tests revealed the time-consolidation properties of the soils in the profile. The results indicated it would take less than ten months to achieve practically full consolidation under an overload which approximated the weight of a full tank.

In certain areas, it was estimated the ground surface would subside as much as two feet during the process. Fortunately, the soil stress calculations indicated this settlement would be reasonably restricted to the area directly under the surcharge itself and would not affect existing structures located some distance away.

The ten month (maximum) pre-load period was not considered excessive in view of the twelve month delivery time for heavy steel plates quoted in the purchase of the tanks. When time is critical, the pre-load period can be cut down considerably by installing sand drains. When time is not critical, the added expense of installing sand drains is unnecessary. Note, however, that sand drains are not readily installed after pre-loading is started.

The pre-load operation was carried out in the field by piling a huge mound of dirt on each tank site. Figure 1 shows the pre-loading in progress at the site of Tank No. 103. Figure 2 shows the pre-load embankments complete at the site of Tanks 17 and 18. After the ground stopped settling under the "pre-load," the dirt was cleared away and used later to construct fire walls. The tanks then were built on sand cushions placed directly on the surface of the ground.

The settling of the original ground surface under the pre-load embankment was measured by noting the change in elevation of observation plates (see Figure 1). A length of pipe welded to each plate and extending up through the pre-load embankment provided a visible point upon which the differential level sights could be made. The observation pole was cased in a larger pipe where it passed through the embankment so that the observation pole could be free to move without interference from the friction of the sur-

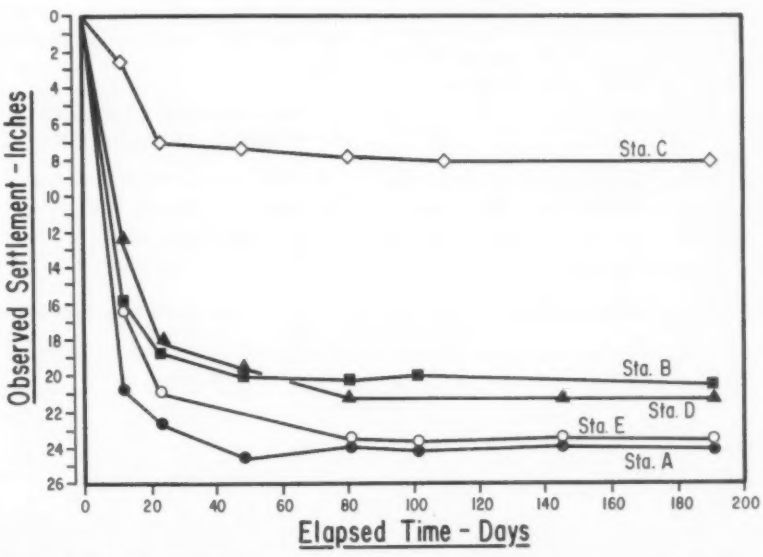


FIGURE 5—The south edge of the tank site was part of an unpaved refinery road. Thus less consolidation occurred at point C.

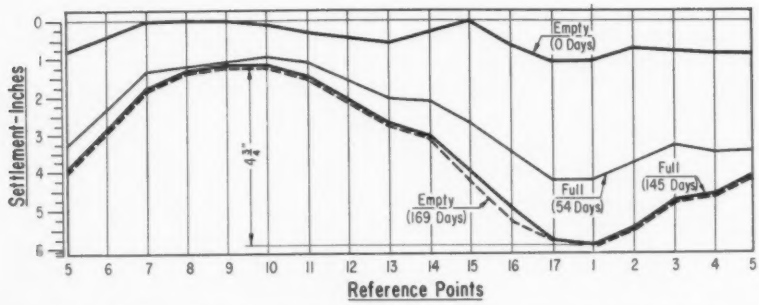


FIGURE 6—Pipe lines along the north side of Tank No. 104 prevented adequate pre-loading to be achieved. Thus the north side of the tank (points 1 and 17) sank during hydrostatic testing.

rounding soil. Settlements observed under pre-loading were very substantial.

For an example of how the method works, Figure 3 represents the pre-load fill placed at the site of Tank No. 104. The location of the observation poles are shown in Figure 4, and the ground settlement which occurred at each of these stations is shown in Figure 5. About 25 days were required to get the pre-loading fill in place.

The differences in settling rate can be explained by a history of the tank site. This area was filled in during the early 1920s with refuse and furnace cinders. The south edge of the site (station C) was part of an unpaved refinery road and was consolidated by vehicular traffic. The rest of the tank site, however, was practically virgin and the fill was in a very loose state of compaction.

A row of existing pipe lines along the north side of the tank conflicted with the toe of the pre-load embankment. A shallow angle of repose was required to keep the earth clear of the pipe lines so that the north side of the tank (station A) was underloaded. This underloading was more evident when the tank was constructed and hydrostatically tested. The north side represented by reference points 1 and 17 in Figure 6 shows how much more the soil was consolidated by the loaded tank.

The other tanks which were constructed on a pre-loaded foundation did not settle as much as Tank No. 104. Furthermore, the other tanks were more level at the end of the hydrostatic test. In all cases, the total and differential settlements were within satisfactory limits and these tanks were placed into service.

The cost savings achieved by pre-loading foundations for the five tanks, as compared to the piled foundations that would otherwise have been required, are summarized in Table 2.

THE EXCAVATE-REPLACE METHOD WORKS, TOO

At the site of one 120-foot x 56-foot floating roof tank (No. 918) a relatively thin layer of fill (7 to 12 feet thick) covered a wedge-shaped layer of organic clay. Laboratory tests showed the organic clay to be soft and very compressible. Building the tank directly on the surface of the ground here was not possible as the east side would settle markedly (greater than 2 feet) and the west side probably not more than 2 inches.

Since the wedge shape represented a fairly small volume of material and the overlying fill was relatively thin, it was decided to strip off the fill and remove the wedge-shaped layer of organic clay. The resulting hole, with a bottom 6 feet deep on the west side and 16 feet deep on the east side, was filled in with clean sand and gravel up to finished grade. The tank was then built on a sand pad placed on the surface of the replacement soil. The reference points are located in Figure 7 and the original tank position is represented by line 1 in Figure 8.

The tank was hydrostatically tested, and measured for settlement at the reference points as shown by line 2 in Figure 8. Under a water level of 50 feet, the 120-foot diameter tank settled 4-13/16 inches differentially to the north.

This marked lean was apparently caused by an abandoned underground sewer line that was broken during the excavation but not plugged. The open ends of the bro-

TABLE 1—Typical Construction Costs for Three 150 Ft. Dia. Piled Tank Foundations (Bayonne, N. J., 1957)

Item	Quantity	COST, DOLLARS				
		Material		Labor		Item Total
		Per Unit	Total	Per Unit	Total	
Piles (approx 30 ft ea)	5,250	0.99/ft length	156,000	1.10/ft length	173,000	329,000
Reinforced Concrete						
Concrete	2,400 cu yd	22.00/cu yd	53,000	30.00/cu yd	72,000	125,000
Reinforcing Steel	220,000 lb	0.06/lb	13,000	0.20/lb	44,000	57,000
Excavation and Sub-Grading	2,100 cu yd	.....	.....	4.30/cu yd	9,000	9,000
Job Total	.....	.....	222,000	.....	298,000	520,000

TABLE 2—Cost Savings By Pre-Loading As Compared to Piled Foundations

Cost Items	Two 75′ x 56′ Floating Roof Tanks 17 & 18	Three 150′ x 50′ Cone Roof Tanks 100, 103, & 104	Totals
Piled Foundations	$100,000	$520,000	$620,000
Pre-Loaded Foundations	30,000	200,000	230,000
Net Savings	70,000	320,000	390,000
Salvage Value of Earth Fill	10,000	60,000	70,000
Gross Savings	$80,000	$380,000	$460,000

TABLE 3—Cost Savings By Excavate-Replace Method As Compared to Piled Foundations

Cost Items	One 120′ x 56′ Floating Roof Tank
Piled Foundations	$120,000
Excavate-Replace Method	
Original Cost	47,000
Jack and Re-Level	3,000
Net Savings	$ 70,000

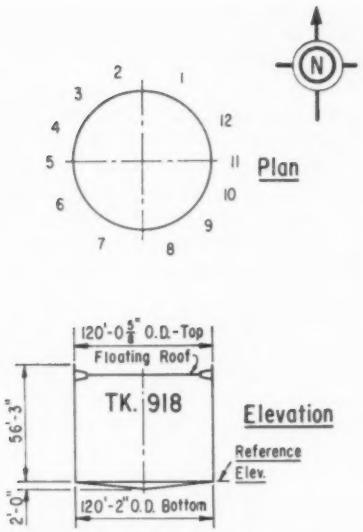


FIGURE 7—Here are the locations of the reference points for Tank No. 918.

ken sewer were about 50 feet on either side of a point tangent to the north side of the shell. A considerable amount of surface runoff from the heavy snow and rain experienced during the test found its way into the broken sewer through four or five open catch basins upstream from the break. The heavy stream of water percolating between the open ends of the sewer undermined the permeable sand and gravel supporting the north side of the tank.

After the cause of the difficulty was located, the abandoned sewer was dug up and the ends sealed with concrete plugs. The tank was jacked up to a near level position as shown in Figure 9. Sand was packed under the raised portion of the bottom, and the tank took the position shown by line 3 in Figure 8. The tank then was hydrostatically tested again. The final settlements under the second hydrostatic test as shown by line 4 in Figure 8 were well within satisfactory limits and the tank was placed into service. The saving achieved by the excavate-replace method over the estimated cost of a piled foundation for this tank is shown in Table 3.

SOME TANKS NEED NO SPECIAL FOUNDATION TREATMENT

Many old structures built on piled foundations at Esso's Bayonne Refinery have been dismantled and the foundations removed, and new structures equal or greater in weight have been erected directly on the surface of the ground. Here again, intensive soil studies revealed the opportunities and limitations for this practice. Where predicted settlements were not objectionable, considerable savings have been achieved by not installing piled foundations where in past years they were considered necessary.

A good example of this is a tank field built in 1955 on the site of one of the refinery's old processing units. Here, eight 150-foot x 50-foot tanks were built providing 1,200,000 barrels of storage. While most of the existing structures removed during site clearance were on piled foundations, each new tank shell was placed only on a crushed stone ringwall with the bottom plates laid on a clean sand cushion.

The purpose of the permeable sand under the bottom plates is to provide a free-draining material that will not hold-up moisture against the bottom plates where it can cause corrosion or freeze during cold weather. The sand also makes a friable subgrade that can be easily worked to the desired elevation and slope. The crushed stone ringwalls retain the sand and provide a stable surface against the erosive action of rain water around the sides of the tank.

The settlement of each tank was measured by the change in elevation of points around the edge of the tank bottom. At the time of this writing, the tankfield has been in service for more than three years, and although differential settlements as great as 4 inches across the 150-foot diameter have occurred, there has been no loss in the usefulness of these tanks.

SOIL INVESTIGATIONS PAY OFF

The technique for making soil borings and obtaining soil samples has reached a high degree of refinement in recent years. This, together with a rapid development of the science of soil mechanics, enables today's competent soils engineer to make accurate predictions of foundation behavior. When investigating the proposed site for a large storage tank, several borings are usually made around the circumference and one in the center.

A typical soil boring is made by driving a 2½-inch or a 4-inch pipe casing into the ground. A standard driving energy is provided by dropping a 300-pound weight through a fall of 12 inches on to the end of the casing. After the casing has been advanced 5 feet, the soil inside the casing is loosened by chopping with a bit connected to a drill rod. The loose cuttings are then washed up and out of the casing with a jet of water.

When the hole is clean down to the bottom of the casing, a soil sample may be obtained. In granular soils that exhibit little or no cohesion between the constituent soil particles, a spoon sample is obtained. This is done by placing a 2-inch O.D., 1⅜-inch I.D. split barrel sampler on the end of a drill rod and driving the sampler into the soil below the end of the casing. The driving energy is usually provided by dropping a 140-pound weight on the end of the drill rod through a fall of 18 inches. A

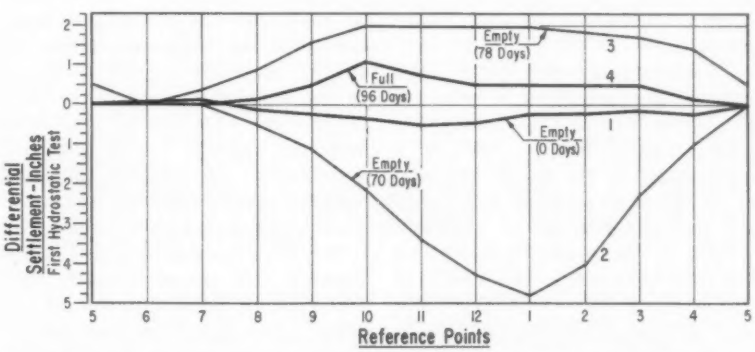


FIGURE 8—The original tank position (line 1) sank during hydrostatic test (line 2). The cause of the sinking was corrected and sand packed under the tank, which then took a new position (line 3). Thereafter, hydrostatic testing caused the tank to sink only slightly (line 4).

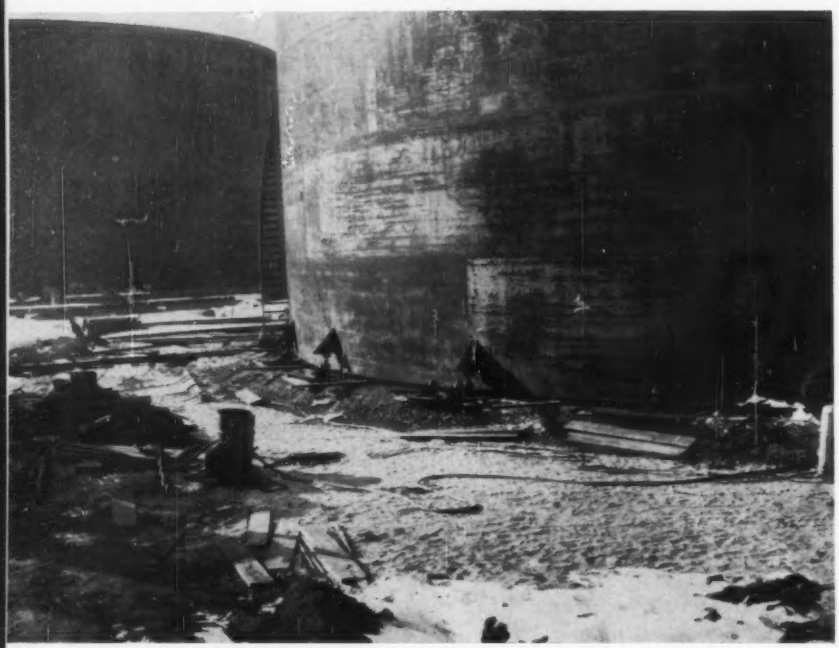


FIGURE 9—Jacks were used on Tank No. 918 to restore it to a more level position.

ball check valve at the top of the sampler permits air to escape as the soil sample advances up the sampler. When the sampler has been driven into the soil a distance of 18 inches it is withdrawn from the hole. Upon withdrawal the ball check valve prevents the return of air into the sampler and the soil sample is held within the sampler by the partial vacuum that occurs as the soil core starts to slip out.

The soil core can be removed from the split barrel sampler by unscrewing the collar and opening the split barrel like the covers of a book. The soil sample thus obtained is placed in jars for later examination in the laboratory.

This process is repeated each time the casing is advanced 5 feet until the boring is completed. Borings are usually carried down to rock, or to a region where the soil is very hard or dense, or to a depth (known as the critical depth) below which the weight of the structure is scarcely felt in comparison to the weight of the overlying soil. This depth is seldom greater than the diameter of the foundation.

During the course of making a soil boring, very significant field data are obtained. The number of blows (300 pounds-12-inch drop) required to advance the casing one foot is recorded for each foot the casing penetrates into the ground. The blow count record for the casing yields an indication of the point resistance plus the total frictional resistance the soil offers the pipe. This can be correlated with the behavior of a pile during driving, should piled foundations be necessary.

The number of blows (140 pounds-18-inch drop), required to advance the split barrel sampler, is recorded for each 6 inches the sampler is driven into the soil below the bottom of the casing. The blow count record on the sampler is primarily an indication of the resistance offered by the soil to penetration by the point of the sampler at the level of sampling only. This can be correlated with the relative density (state of compaction) of granular soils and with the relative consistency (natural shear strength) of clayey soils.

When soft, plastic or highly compressible soils are encountered, they will play an important role in the behavior of any foundation placed directly on the surface of the ground. A soft, plastic soil may fail by shearing under the imposed foundation loading, or a compressible soil will consolidate under the foundation and thus cause a settlement that may reach an excessive stage.

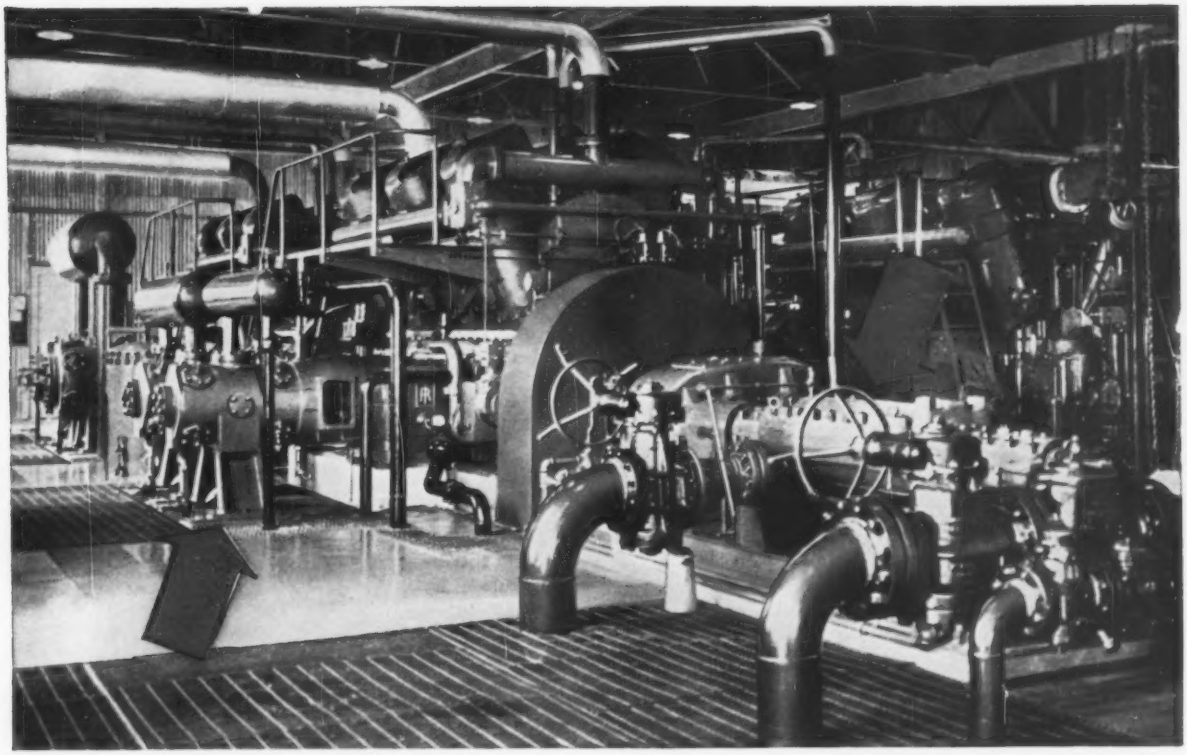
When this type of soil is discovered in a soil boring, an undisturbed sample is obtained so that careful laboratory strength tests can be made on the specimen which is maintained in a state that is truly representative of the soil in its natural deposit. These undisturbed samples are usually obtained by substituting a 3-inch diameter thin-walled cylinder with sharpened edges for the split barrel sampler described earlier. The thin-walled tube is carefully pushed into the cohesive soil layer by the static weight of the drill rod or by jacking. If the cohesive soil sample is disturbed or re-molded it will exhibit markedly different properties in the laboratory. Extreme care is exercised in obtaining and handling undisturbed soil samples. Tri-axial compression and consolidation tests are usually made on the undisturbed soil samples, and the results of these tests are used to predict the settlement a given load will cause and the factor of safety against a shear failure.

ACKNOWLEDGMENT

The author wishes to thank Dr. D. M. Burmister of Columbia University for assisting in studies of the pre-load method, making laboratory soil tests, and predicting the time required for satisfactory soil consolidation.

About the Author

E. T. DiCorcia is a group head in the Process Engineering Division, Esso Standard Oil Co., Bayonne, N. J. He is in charge of process design and technical service work for the asphalt manufacturing, utilities, and fuel products terminalling operations of the Bayonne refinery. A registered professional engineer in New Jersey, DiCorcia has a B.A. degree and B.S. and M.S. degrees in civil engineering from Columbia University. He is a member of Tau Beta Pi.



DOUBLE-DUTY GAS-ENGINE COMPRESSORS

compress recycle gas *and* drive lean oil pumps

At Skelly Oil Company's Schafer gasoline plant in Skellytown, Texas, the two Ingersoll-Rand 660-hp KVG gas-engine compressors shown above serve dual functions: they compress recycle gas *and* pump lean oil!

In addition to its built-in compressor cylinders, each gas-engine unit also drives an Ingersoll-Rand HMTA eight-stage centrifugal pump, connected to the flywheel end through speed-increasing gears. The two compressors handle 4 to 5 million cubic feet per day of recycle gas at 335 psia intake, 845 psia discharge. And the pumps circulate 906 gpm of lean oil to the absorber at 875 psi.

These versatile 4-cycle V-angle engine-compressors can be used for compression alone, for pump drive alone, or for simultaneous pumping and compression. Compared to the normal practice of using separately-driven pumps, the combination units result in substantial savings in equipment cost, space and installations costs, and operating expense.

Special applications like this are made possible by Ingersoll-Rand's flexible, 4-cycle V-angle engine design, with its excellent balance and smooth-running characteristics under any load and at any speed down to half. Other I-R engine-compressors are in use at the same plant, and their dependable performance was influential in the selection of the double-duty machines.

For maximum economy and dependability, it will pay you to check the unique advantages of Ingersoll-Rand 4-cycle V-angle diesel and gas-engine compressors and power units. Your I-R representative will be glad to give you complete information.

ONLY I-R COMPRESSORS HAVE CHANNEL VALVES

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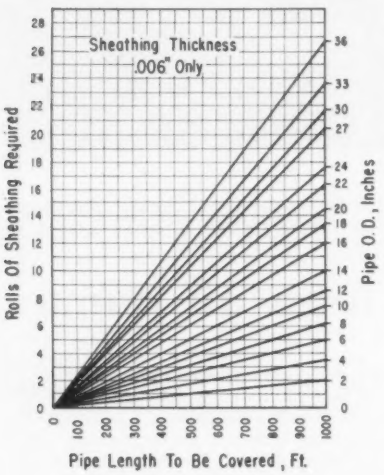
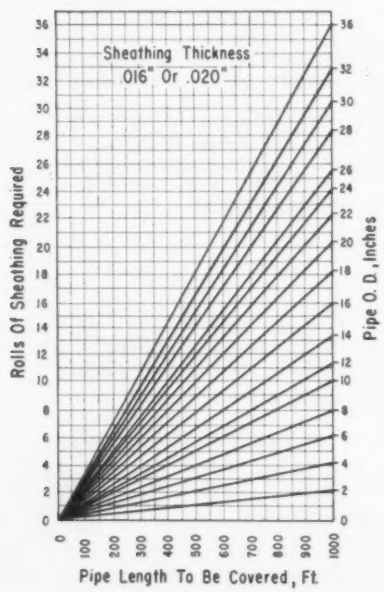
How to Do It...

Charts Calculate Sheathing Quickly

It's easy to figure the number of rolls of sheathing needed to cover a given section of insulated line

Striving for a better looking, more durable, weather coating for insulated lines than the rubberoid-type roofing material, one company tried aluminum and galvanized sheet stock. With aluminum prices steadily lowering, that material is currently standard. Aluminum sheet works up more readily and lasts longer.





Illustrated are two charts that proved extremely useful in calculating the number of rolls of sheathing needed to cover a given section of line.

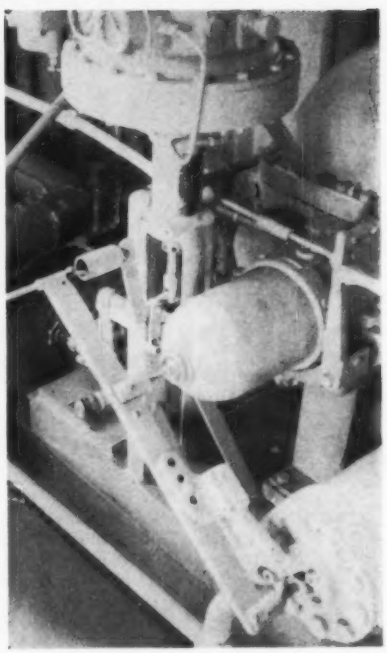
Once insulation craftsmen have made the turns smoothly, as well as the tees, insulation can be covered permanently by using the excellent new die-formed bootees. Specifications allow them to be snapped into place to form a tight seal with the aluminum jacketing placed on the pipe itself. Fastening is by metal holding screws run through the 2-inch overlap.

The aluminum has proven quite resistive to fumes common around refineries, and the occasional drip that may occur at leaks along the lines.

To use the chart, enter the correct sheathing-thickness chart at the right-hand side on the O.D. of the pipe to be covered. Follow down the slant line to the intersection of the vertical line corresponding to the pipe length to be covered. Extend the intersection horizontally to the left and read the rolls of sheathing required. (Note: Each roll covers 100 square feet and is 48 inches wide and 25 feet long.)

The aluminum tie bands blend well with the general ensemble for a very professional looking appearance throughout the installation. For purists who desire something extra special to decorate lines passing the administration building's formal lawns, anodized aluminum is available in many beautiful pastel shades.

This idea was submitted by Paul C. Ziemke, Clinton, Tenn.

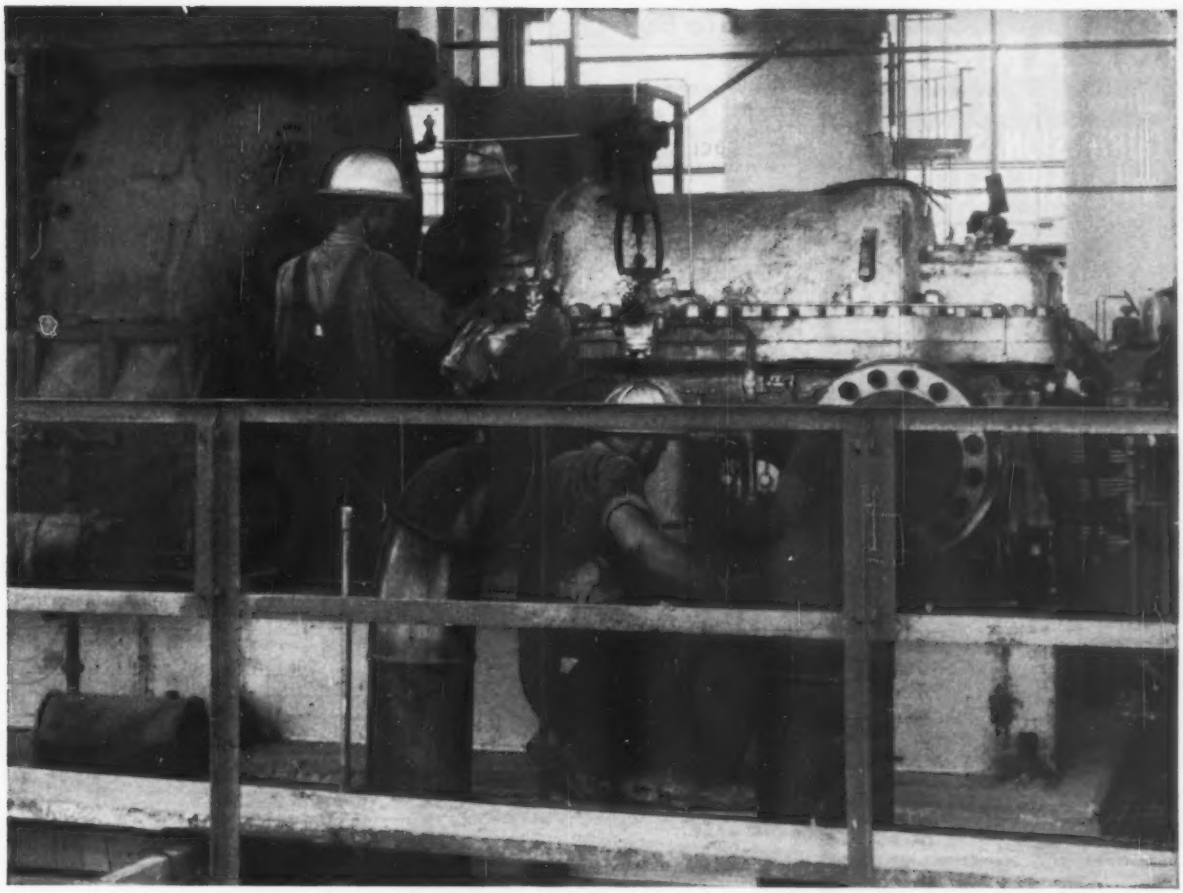


Controller Cuts Compressor Maintenance Expenses

One plant was using an air compressor with such heavy instrument air demand that the compressor unloaded every seven seconds. The compressor was designed for 600 cfm of air at 75 psi discharge pressure, operating at 600 rpm and normally on turbine governor control.

Because of the operating speed and the unloading frequency, 10 to 20 maintenance manhours per month were required on the compressor. This work primarily involved channel valve wear, carbon ring wear and checking the unloading assembly.

To solve these problems, a pressure controller diaphragm, yoke-stem as-



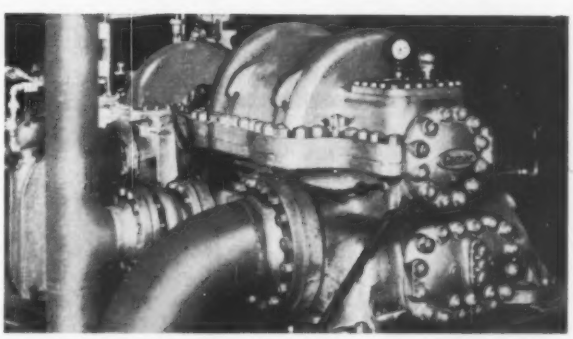
Ethylene compressor being installed at refinery of leading oil company for operation at 600 psi, as low as −185° F. Compressor halves are cast from 4½% nickel steel to resist low temperature impact.

New ethylene compressor works at −185°F ...it's made of cast 4½% nickel alloy steel

Temperatures down to −185°F . . . pressures up to 600 pounds per square inch . . . mean greater efficiency for this ethylene compressor. But these extreme operating conditions increase the danger of low temperature embrittlement. To protect the compressor against cracking, Carrier Corporation of Syracuse, N. Y., specifies cover and base in 4½% Nickel, low carbon steel . . . an alloy with remarkable impact strength at "deep frozen" temperatures.

For the compressor impeller, designers specified heat-treated 2340, 3½% nickel alloy steel. This forged steel, too, provides strength and toughness at low temperature.

Where low temperature puts special emphasis on shock resistance in your process equipment, it will pay you to check the advantages of cast or wrought nickel alloy steels.



Closeup of #350 Carrier compressor, similar to unit shown above. 4½% nickel steel cast upper half weighs 4200 lb, lower half, 5800 lb.

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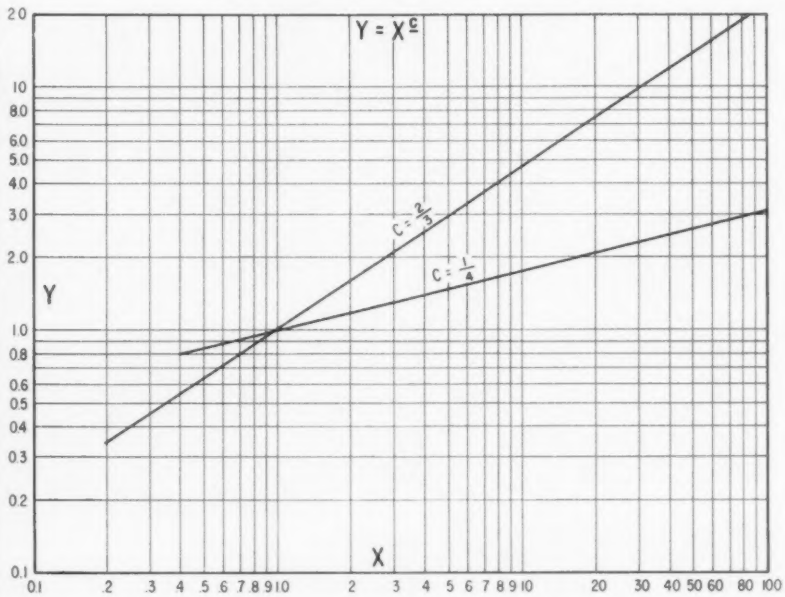
How To Do It . . .

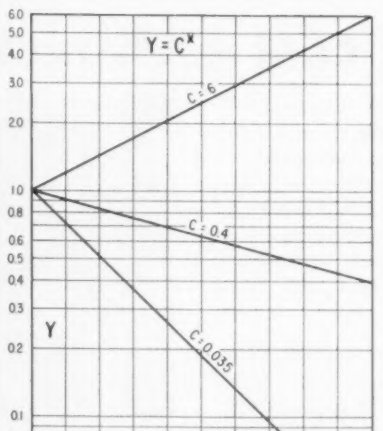
sembly (shown in the photo) was installed. The assembly operates through a linkage to the compressor governor-control stem. The pressure controller is actuated by the compressor discharge pressure. When discharge pressure falls off, the compressor speeds up. Conversely, when pressure builds up, the compressor slows down.

The system reduced the compressor unloading time materially, which in turn cut maintenance costs to a nominal amount expected for a compressor of this type.

This idea was submitted by Pete South, El Paso Natural Gas Products Co., Gallup, N.M.



Log Paper Solves Exponentials



Usually in numerically solving exponential functions one resorts either to a log-log slide rule or a table of logarithms. However, these functions can be conveniently solved by use of either log-log or semi-log paper.

Exponential functions appear in two forms:

$$Y = X^C \text{ and } Y = C^X$$

Putting these equations in logarithmic form results in—

$$1 \text{ Log } Y = (C) \text{ Log } X$$
$$2 \text{ Log } Y = (\text{Log } C)\ X$$

The first equation will be a straight line on log-log paper with a slope of C and can be plotted either by obtaining two points, or by obtaining one point and the slope. It can be seen that when $X = 1$, $Y = 1$. In heat exchange problems, the functions $\left(\frac{C\mu}{k}\right)^{2/3}$ and $\left(\frac{\Delta T}{d\sigma}\right)^{1/4}$ frequently appear. These functions have the

How To Do It . . .

form $Y = X^c$ and are plotted as Figure 1. They have slopes of 2/3 and 1/4 respectively and pass through the point $X = 1, Y = 1$.

The second equation will be a straight line on semi-log paper and can be plotted by any of the standard procedures. It should be noted that when $X = O$, $Y = 1$ and when $X = 1$, $Y = C$. Figure 2 plots the functions $Y = 6^X$, $Y = 0.4^X$, and $Y = 0.035^X$. If it is desired to find the value of $0.035^{0.22}$, it is only necessary to draw a straight line on semi-log paper through the point $X = O$, $Y = 1$ and $X = 1$, $Y = 0.035$, and read for $X = 0.22$ the value of 0.48.

Both methods, of course, solve the same basic function and each method has certain advantages. The log-log method is useful in representing functions such as $(C\mu/k)^{2/3}$ where the exponent is constant and when the function appears numerous times in various problems.

Although it might appear that these methods are particularly useful if a log-log slide rule is not available, they, in fact, have some inherent advantages over a slide rule. On most log-log slide rules you have to resort to tricks, if the value of the function is below 0.0001 or above 20,000. In addition, the log-log scale on a slide rule does not have any constant accuracy and becomes very inaccurate on both ends of the scale. These disadvantages are not encountered with the above methods.

This idea was submitted by Benjamin Smith, Koppers Co., Inc., Pittsburgh.

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At least $10 will be paid for each idea accepted for "How to Do It." Just send a brief note with a photo or sketch to the Editor, *Petroleum Refiner*, P. O. Box 2608, Houston.

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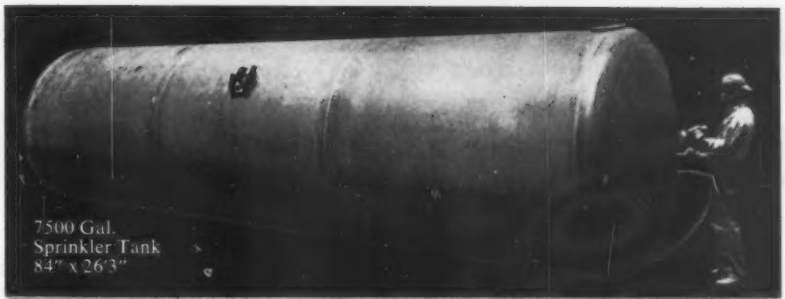

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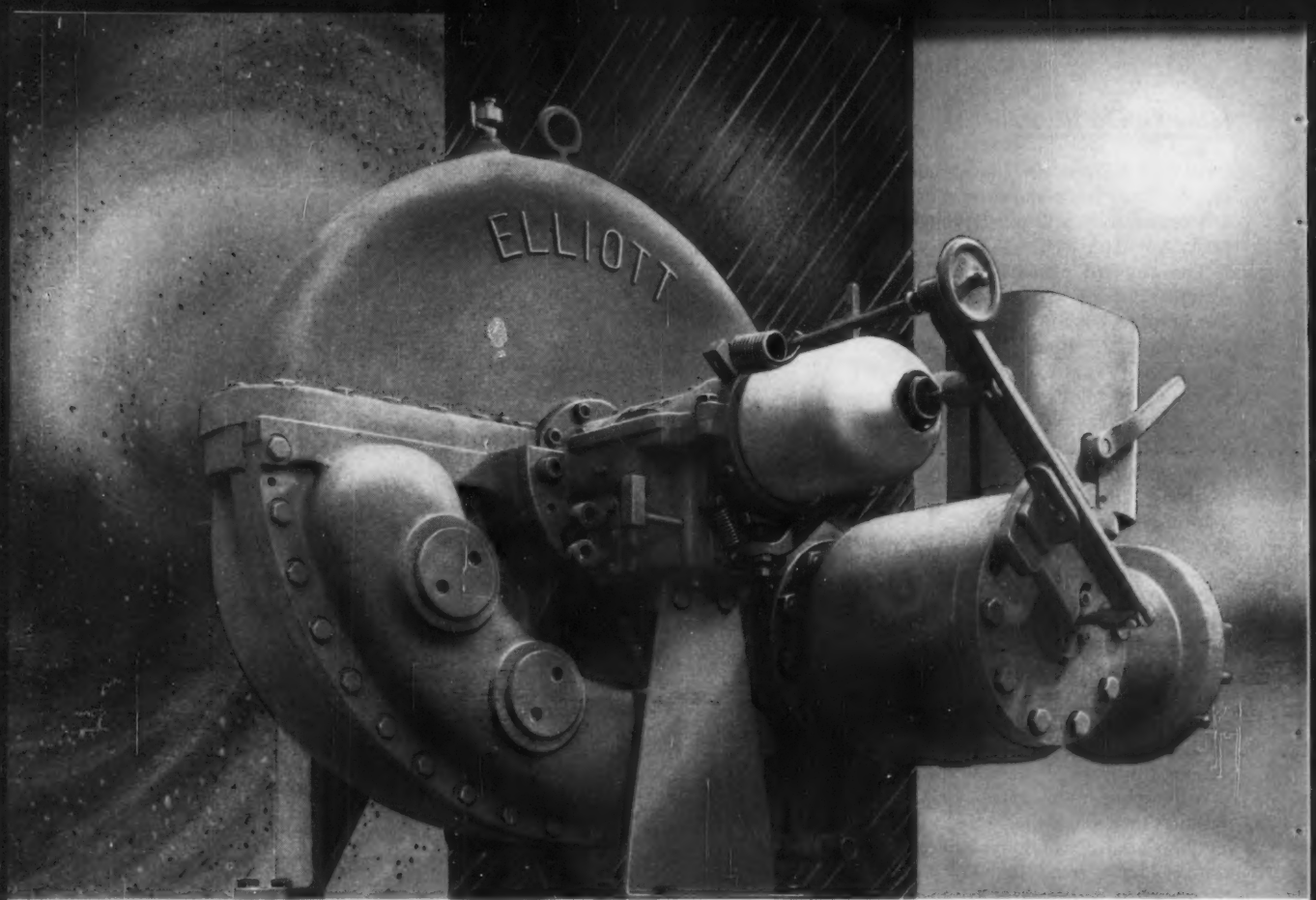

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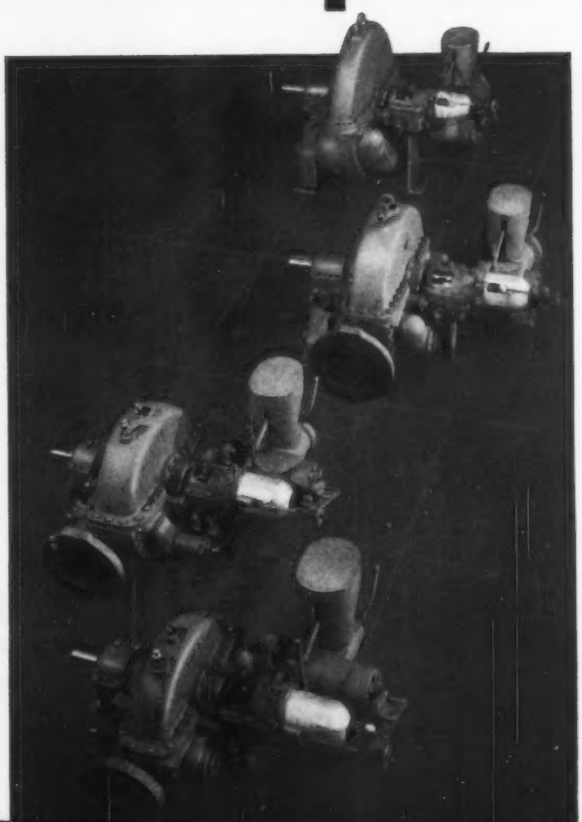
The governor is simple and reliable, and is available in several modifications to match speed and pressure control requirements. YR turbines are designed for easy installation and service. Many key parts are interchangeable for various frame sizes. Four sizes are shown at the right. Write for descriptive bulletin H22-C.



In addition to the units illustrated here, Elliott makes single-stage turbines in special frames, reduction gears, multistage mechanical drive turbines to 50,000 hp, and turbine-generators through 44 mw.

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Who's Building...

Up They Go!

Three carbon dioxide absorbers are being erected by Brown & Root for Transwestern Pipeline Co.'s gas treating plant near Fort Stockton, Texas. These absorbers will operate at 1,000 psi, are 84 inches in diameter, and weigh 91 tons each.

Gas Removal Plant for Transwestern

This first U.S. installation to employ the Giammarco-Vetrocoke process for acid gas removal, will treat 180 MMcf per day of 1,050 psig natural gas

The first U. S. installation to use the Giammarco-Vetrocoke process for acid gas removal is ready for operation near Fort Stockton, Texas. The plant was designed and constructed under license by Brown & Root, Inc., for Transwestern Pipeline Co. It will treat 180 MMcf daily of 1,050 psig natural gas containing 28 percent carbon dioxide and up to 0.2 percent hydrogen sulfide.

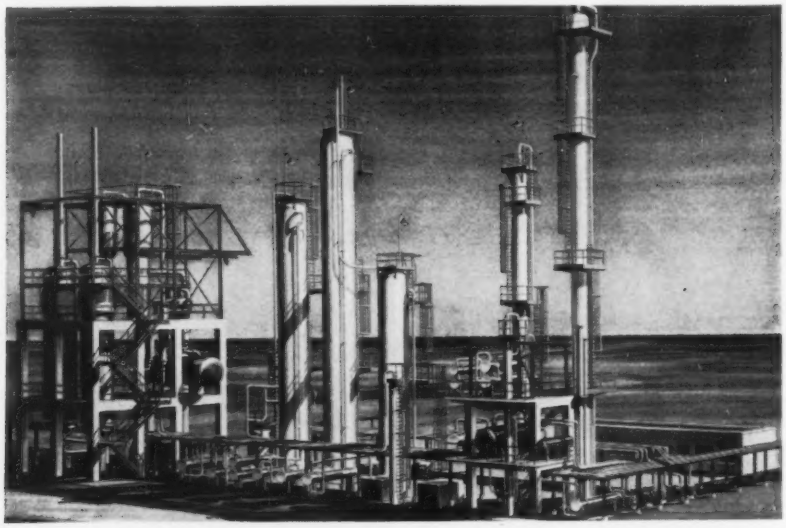
The unit will produce a dehydrated pipeline sales gas essentially free of hydrogen sulfide and with less than two percent carbon dioxide. It will use less than 4 MMcf of sour gas daily to develop installed generating capacity of only 1,800 kw and 120,000 pounds per hour of steam at 600 psig and 750° F.

Although the plant is ready for operation, actual start-up will be timed to match completion of Transwestern's pipe line from Texas to California. The plant will be the first to utilize power recovery pumps in large horsepower sizes, over 1,000 hp per pump on the main solution circulation system.

Gulf Oil Corp. has completed a new multi-million-dollar high-purity cyclohexane plant at its Port Arthur, Texas, refinery. Initial production is scheduled for this month. This new plant will manufacture a high-purity-grade product especially adapted to nylon. It will also be used as a solvent in the manufacture of polyethylene and as a raw material for

Building . . .

the manufacture of plasticizers and synthetic lubricants. Benzene used as a raw material for the new plant will be supplied from the large benzene unit brought on stream by Gulf in June 1959. The new plant will be the first such installation by an oil company producing cyclohexane from benzene, according to the company. It is being built by Procon, Inc., and uses a process licensed and engineered by Universal Oil Products.



Artist's drawing shows layout of new Brandenburg, Ky., Doe Run works.

Ethylene Oxide Plant for Olin Mathieson

Olin Mathieson Chemical Corp.'s new ethylene oxide plant at Doe Run works, Brandenburg, Ky., is scheduled to go on stream late in 1960. Engineered and constructed by The Lummus Co., the plant will employ Shell Development Co's. process for the direct oxidation of ethylene to ethylene oxide. The ethylene oxide product will be converted into derivatives for use in the manufacture of antifreeze, industrial coolants, hydraulic brake fluids, detergents and chemical intermediates. Feed for the new plant will come from Olin Mathieson's ethylene plant, also located at Doe Run. The new plant is part of a recently announced $30-million expansion program for the company's Chemical Division.

Texaco Inc. plans to triple present capacity of its 100,000-barrel butane storage well S2 in the Sour Lake field, Texas. Expansion of the underground cavity in the Salt Dome where well S2 is located began last month and is scheduled for completion by late spring. A leaching process, using water to dissolve the salt, will be employed. With completion of the present expansion program, total capacity of Texaco's underground butane storage at Sour Lake field will amount to 800,000 barrels. This includes one other 300,000-barrel and two additional 100,000-barrel cavities. Butane is stored at Sour Lake field for use at Texaco's Port Arthur works, 45 miles to the east.

Sincat S.p.A is building a new ethylene plant in Sicily. Designed and constructed by Stone & Webster Ltd., London, and slated to be completed this spring, the plant will be part of an integrated chemical manufacturing complex being developed at Priolo, a town north of Syracuse, by Sincat, which is owned by the Societa Edison group.

DX Sunray Oil Co. is planning construction of a Udex unit designed to produce 600 bpd of benzene at its Tulsa refinery. Construction will start March 1, and the unit is scheduled to go on stream October 1. The $1-million construction project is part of a long-range expansion program to diversify the company's output of refined products. One of the plant's catalytic reforming units will take select fractions from a crude unit and convert them into benzene and other compounds. The Udex unit will recover and purify the benzene. In addition, the unit will also produce 300 bpd of toluene. The Refinery Engineering Co. has been awarded the construction contract.

Monsanto Chemical Co. has begun a major modernization of phenol production facilities at its William G. Krummrich plant, Monsanto, Ill., to be completed by mid-1961. The unit, one of the nation's major sources of phenol will incorporate the latest process technology, equipment and controls, while retaining its basic process.

Pan American Petroleum Corp. and Hondo Oil and Gas Co. have begun preliminary field work on construction of their Empire Abo gasoline plant near Artesia, N. M. Site clearing and drilling of test holes has begun at the plant site—13 miles southeast of Artesia. The construction coordinator for the prime contractor is O. L. Olsen Co., Inc., Houston. While preliminary work is being done by Pan Am personnel, Olsen crews will handle actual construction of plant facilities. Surveying of right-of-way for the field gas gathering system is also under way. The plant is to be completed and ready to start gas processing operations by June 1. Located on a 20-acre site, it will have an initial compressor capacity of 10 MMcf of gas per day, with processing vessels designed for a capacity of 15 MMcf per day. When operating at design rates, the plant will recover 42,000 gallons a day of liquid product—propane, butane and natural gasoline. Sulfur will also be recovered in a special unit designed for this purpose by Pan Am.

Imperial Chemical Industries, Inc. made rapid progress in 1959 on construction of its polypropylene plant at Wilton, Yorkshire, England. Latest reports from engineers on this job indicate that the 10,000-ton-per-year plant will be on stream towards the end of this year. Earlier, it was expected that the plant would not be ready before 1961. The site is fully developed, roads have been laid and buildings completed—ready for processing equipment to be installed. The plant will be the first for commercial-scale polypropylene in England. Alongside the synthesis plant, the Plastics Division will produce organo-aluminum compounds in bulk for use as catalysts in the process. ICI first announced plans to extend its polyolefin activities last April. Since last May, the company has been selling polypropylene in order to develop the market. (See story on ICI olefin expansion at Wilton. PETROLEUM REFINER, November 1959 issue, page 322.)

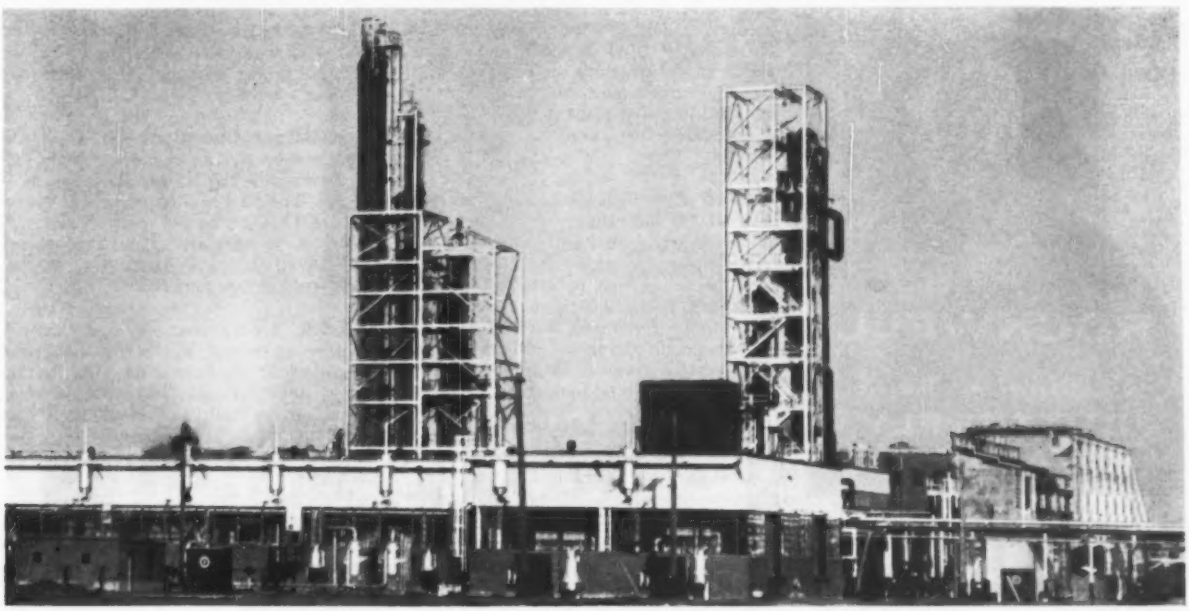
Mobil International Corp. reports that the prime minister of Turkey, Adnan Menderes, has laid the cornerstone of a $50-million refinery at Mersin in Southeast Turkey. The project is also being financed by Royal Dutch Shell and British Petroleum Corp., whose shares in it will be 27 percent and 17 percent, respectively. Mobil will hold a 56 percent share. The Mersin refinery, which will have a capacity of 65,000 bpd, will be built by Foster Wheeler Ltd., and is expected to go on stream in the latter half of 1961.

Ashland Oil & Refining Co. is planning to build a new plant at its Buffalo, N. Y., refinery to make 50 million pounds per year of naphthalene or 12 million gallons per year of benzene, or a combination of the two. The plant will use a hydrodealkylation process, developed by Ashland, which will convert alkyl benzene and alkyl naphthalenes into naphthalene. The plant will be the first to

ENGINEERS AND CONSTRUCTORS FOR INDUSTRY

ETHYLENE PLANT EXPANSION ON STREAM FOR CANADIAN INDUSTRIES LIMITED

Lummus Designs and Engineers 85% Expansion of Ethylene Plant at Edmonton, Alberta, Canada



Expansion of C-I-L's ethylene facilities at Edmonton, Alberta, Canada, is completed and the plant now has a capacity of 46 million lbs. per year of high purity ethylene. The entire output of this unit is used by C-I-L to manufacture polyethylene.

Lummus designed and engineered the expansion of the existing cracking facilities, built in 1953, for the increased production of ethylene, and the ethane recovery unit for extracting ethane from natural gas.

As originally designed, the plant recovered ethylene from the cracking heater effluent and ethane from natural gas by oil absorption. In the expanded plant additional capacity is obtained by withdrawing the natural gas portion and increasing the heater effluent.

The new low temperature ethane recovery plant has a demethanization unit which utilizes ethylene refrigeration to temperatures as low as −145°F. At C-I-L's request sufficient capacity has been designed into this unit to permit another expansion step in the future.

Up-to-date equipment was employed to ensure economical and efficient operation. Special efforts were made, wherever possible, to incorporate existing equipment into the expanded plant.

In addition to the C-I-L expansion project, Lummus has designed 13 complete ethylene plants, with a combined total capacity of over one billion pounds per year.

Over 800 plants have been designed, engineered and constructed by Lummus for the process industry throughout the world in the last fifty years. Why not discuss your next project with a Lummus representative?

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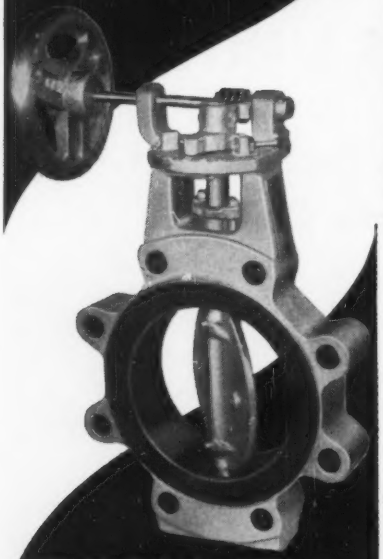

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Building . . .

produce synthetic benzene and naphthalene from petroleum, according to the company. Considerable amounts of benzene are currently made in catalytic reformers by dehydrogenating cyclohexane, and by ring enlargement of methyl cyclopentane. The Ashland process will be "the first to produce benzene by dealkylation."

U. S. Rubber Co. is expanding capacity of its Naugatuck Chemical Division's vinyl resin plant in Painesville, Ohio, by more than 30 percent. Completion is scheduled for July and the plant will have an approximate capacity of 65 million pounds annually when completed. Emphasis in this new expansion program will be placed on lifting the plant's capacity to produce plastisol-grade vinyl resin.

Monsanto Chemical Co. has begun construction of facilities for the manufacture of various alkyl phenols at its Kearny, N. J., plant. Most of the plant's production will be used to make alkyl phenol-based ethylene oxide condensates. Engineers constructing the plant are using modeling techniques to speed construction and improve plant design. The plant is scheduled for completion in September 1960.

Poland plans to begin construction soon on a 40,000-bpd refinery at Plock, Northwest of Warsaw, that will triple the country's refining capacity. The plant, scheduled for completion in 1965, will fill 70 percent of Poland's local demand. It will also supply feedstocks for an adjacent petrochemical complex. Crude oil for the plant will be received through a Russia-Eastern Europe pipe line, currently under construction.

Regent Refining (Canada) Ltd., a subsidiary of Texaco Canada, Ltd., plans to install a 4,700-bpd catalytic reformer at its Port Credit, Ont., refinery. The unit replaces one with a 2,000-bpd capacity, and is designed to improve the refinery's gasoline quality. The $1.5-million reformer, to be built by Catalytic Construction of Canada, Ltd., is to be completed by September.

Imperial Oil Ltd. has completed a $14-million expansion of its Calgary, Alba., refinery. Capacity of the plant was increased to 14,700 bpd. The original plant was built in 1922 and had a 4,000-bpd capacity. Units at the refinery include distillation, catalytic cracking, reforming and alkylation, all of which are computer controlled.

California Texas Oil Co. has reportedly signed an agreement with the Turkish Government for construction of a refinery at Istanbul. The new plant's capacity, when combined with that of the Mersin refinery, will provide the country with a "considerable surplus of refined products for export."

Signal Oil & Gas Co. is considering a large expansion of a refinery operated by Eastern States Petroleum & Chemical Corp., Houston, a subsidiary. Throughput of the 60,000-bpd plant will be increased, and units installed to upgrade products. A company spokesman said that no starting date has been set, but that the company is planning a substantial outlay of millions of dollars over several years.

Hercules Powder Co. is planning to build an 8-million-gallon-per-year methanol plant on its Hercules, Calif., plant site, near Richmond, Calif. The company also plans an 11,000-ton-per-year plant for urea-formaldehyde compositions, and a 50-million-pound-per-year formaldehyde unit. Completion of the methanol-formaldehyde facilities is slated for early 1961, while the urea-formaldehyde unit is to be on stream by the middle of this year.

N. V. Maatschappij Tot Exploitatie Van Kooksovengassen, Ijmuiden, Holland, plans to build a gas reforming plant to treat natural gas for the production of ammonia synthesis gas. The 4.4-MMcf-per-day plant is followed by a CO conversion plant producing gas to send to the existing purification and ammonia synthesis plant.

Asahi-Dow Chemical Co.'s 18,000-ton-per-year styrene monomer plant has been completed at Kawasaki, Japan, near Tokyo. The $4.4-million plant will manufacture 12,000 tons per year of raw material for styrol plastics, and the balance will go to Japanese Geon Co. as synthetic-rubber raw material.

U.S.S.R. reports that the first "major" refinery in central Siberia has gone into operation at Angarsk on the Angara River, near Irkutsk. Currently receiving crude oil by rail, the plant is to get feedstock through a 2,300-mile pipe line from the Tuimazy oilfields by the end of this year.

Phillips-Joanna Co. has been formed by Phillips Petroleum Co. and Joanna Western Mills Co. to produce polyethylene film in a processing plant near completion at Ladd, Ill. The firm will manufacture both linear and conventional polyethylene film in low and medium densities

Rumania has completed two new catalytic cracking installations at its refinery. Initial crude runs took place about three months ahead of schedule. With construction of the new plant and modernization of old ones, Rumania is processing her entire output of crude oil.

International Synthetic Rubber Co., Ltd. has started construction of a new plant at Hythe, Southampton, England, to produce general-purpose synthetic rubber latex. The $18-million plant is designed to produce $2.5 million gallons of rubber latex a year. Britain's first

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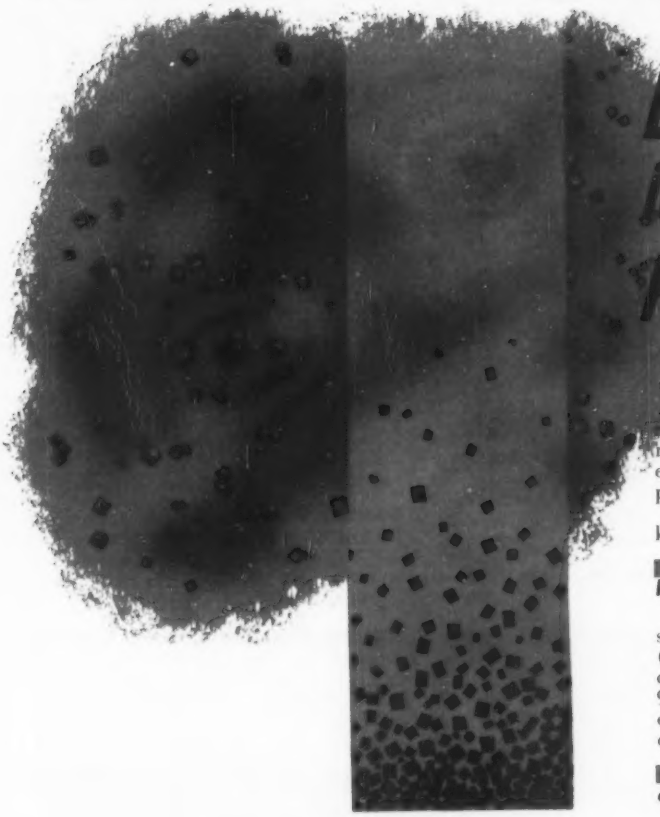

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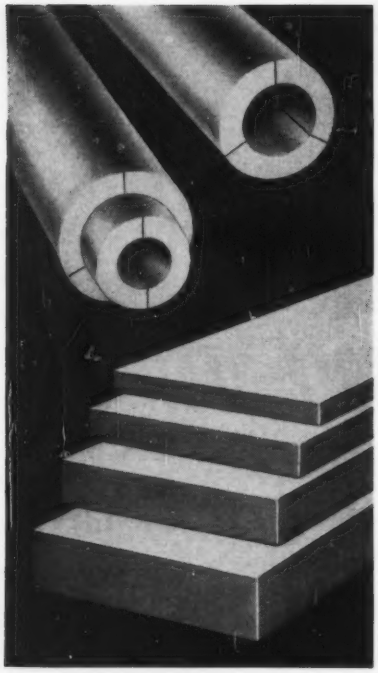

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Building . . .

venture in the bulk manufacture of general-purpose synthetic rubber, the plant has a capacity of 70,000 tons a year.

Avi-Sun Corp. has completed a plant to produce high-clarity, high-strength polypropylene film, at New Castle, Del. The 10-million-pound-per-year plant will get polypropylene feedstock from Avi-Sun's new polypropylene unit at Port Reading, N. J.

Matias de Galvez, Ltd., a new refining firm formed by Breaux Bridge Refining Co. and Shell Oil Co., has started work on Central America's first refinery, a 3,500-bpd plant near Puerto Barrios. The new company was named for the Caribbean port where it is being built. The Lummus Co. is handling engineering and construction of the plant.

Borden Chemical Co. has begun construction of a 47,500-ton-per-year resin and formaldehyde plant near San Francisco, Calif. The plant will produce 25,000 tons per year of resin, and 22,500 tons per year of formaldehyde for adhesive and paint manufacture.

Mobay Chemical Co. still in the process of upping capacity of its tolyene diisocyanate plant at New Martinsville, W. Va., from 12 million to 18 million pounds per year, has decided to further increase capacity to 25 million pounds per year. The latter expansion is to be completed in July.

Borden Chemical Co. has completed construction of a new pilot plant at Leominster, Mass. The initial step in a projected $2-million expansion, the new unit is designed to produce 1,000-pound lots of polyvinyl alcohol, polyvinyl acetate, acrylics, and butadiene-styrene.

U.S.S.R. is said to be planning a polystyrene plant to be completed this year. A $1.8-million plant has been ordered by the Soviet Union from P. G. Engineering, Ltd., a subsidiary of Power-Gas Corp., Ltd. The unit will produce 9,000 long tons annually.

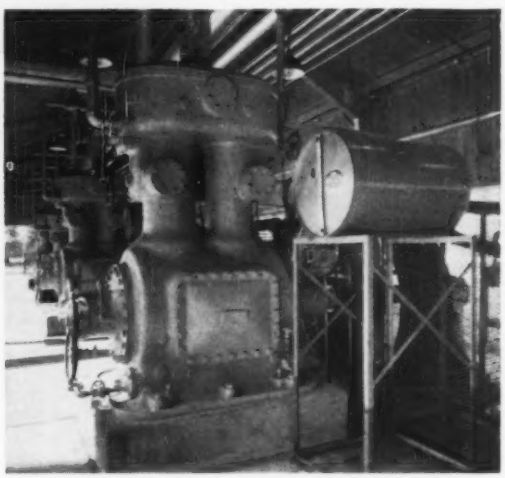
Korea has started operation of its new $40-million urea plant at Chung-Ju, South Korea. The 270-ton-per-day plant was engineered by Vulcan-Cincinnati, Inc., and will use the Inventa-Vulcan process.

Carwin Co. plans to build a new plant at Houston to make special isocyanates for use in high-temperature foamed plastics. The 500,000-pound-per-year plant can be doubled by minor additions.

Suntide Refining Co. has completed construction of a new delayed coking unit at its Corpus Christi, Texas, plant. The unit was built by The Refinery Engineering Co.

Aurora Gasoline Co. has completed construction of a new sulfuric-acid alkylation unit at its Detroit refinery. The unit was built by The Refinery Engineering Co.

Condensing Gasoline for H. L. HUNT



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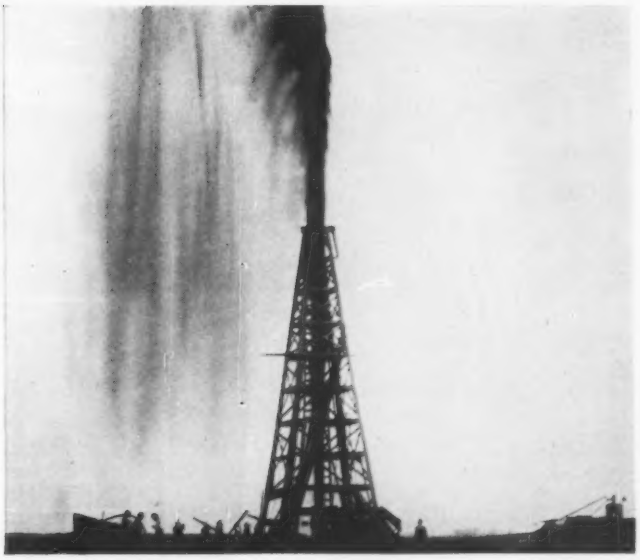

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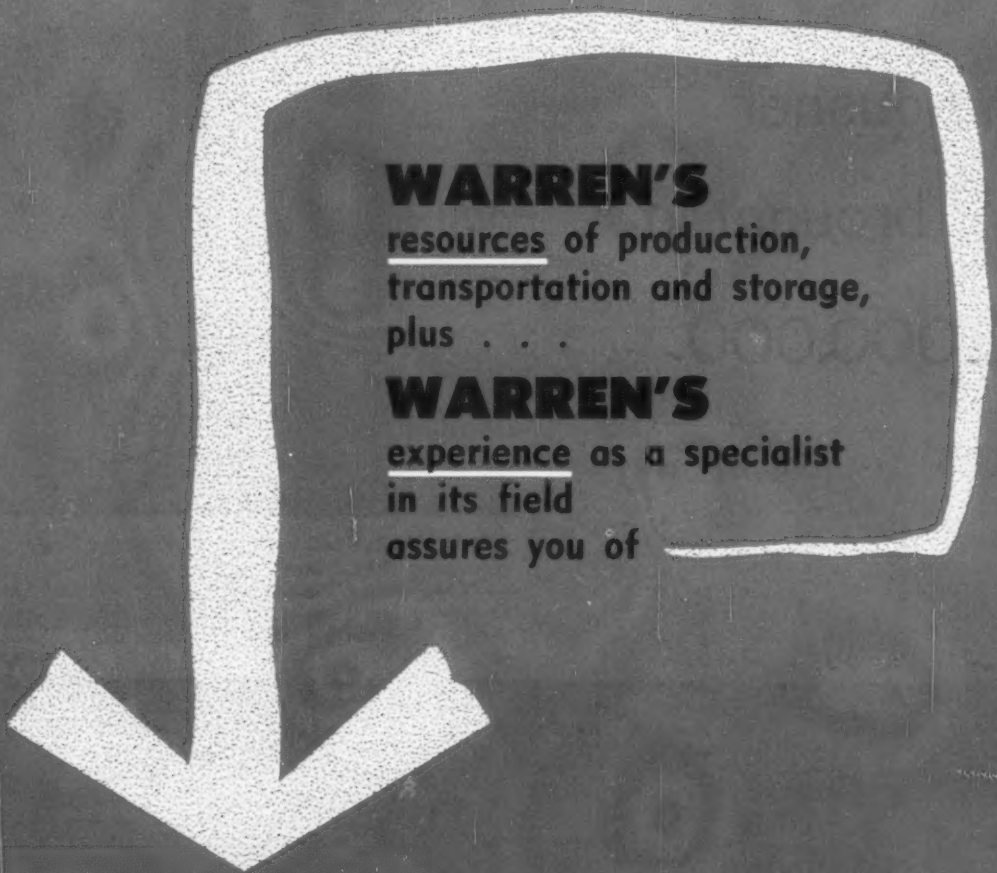

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Employe Health— A Management Function

Keeping workers healthy as well as happy is essential to industry. However, management must realize that curing mental and physical ailments is not enough—a preventive approach is also necessary

David F. Tver, Petty
Geophysical Engineering Co.
San Antonio, Texas

THERE WAS a time when management's only concern for the health and safety of the worker was confined to first aid and calling in a physician in case of a serious injury. The health of an employe was his own personal business. The job was presented with all its hazards and if the applicant desired the job, he also accepted the working conditions. If he became ill, it was at his own expense, including time lost because of the illness. If he was injured it was attributed to his own carelessness.

Industry has come a long way since then in establishing industrial health programs, although comprehensive medical programs are still limited in most part to the larger companies. Until recent years, small and medium-sized organizations did without medical or health programs or else maintained a physician on a retainer basis for pre-employment physicals and treatment of industrial injuries. However, there has been a recent trend in small companies to combine into cooperative units. In this way, small companies can afford medical services which they might not be able to finance alone.

The Changing Scene. These advances in industrial medicine and hygiene have come about because of many reasons, the most important being the realization of companies that the employe's health and working conditions are directly related to productivity. Organizations now realize that they are part of the community, and as such, they have a certain degree of responsibility to the community.

Company unions have also been a factor in forcing many changes on industrial organizations through bargaining on safety and working conditions. There has been an attitude by many unions recently that health programs should be financed by industry but operated by the union. Such examples of this are the programs established by the Amalgamated Clothing Workers, Restaurant Workers, United Mine Workers and the Willys-Overland Local of the United Automobile Workers.

In addition to these forces there are many state laws being passed which indemnify the employe for lost time due to non-occupational illness. It is to the employer's advantage, therefore, to maintain a healthy working force. All these factors have combined to force industry into complete medical and health programs which have been benefited both employer and employe.

Soaring Costs. The cost of illness to industry, both real and imaginary, is almost incalculable. It has been estimated that about 500 million man-days are lost annually because of illness, the equivalent of approximately two million men working full time. This cost is estimated at $10 billion.

Another survey indicates time lost from off-the-job accidents and illnesses averages more than 13 days per year per worker of which three-fourths are due to common and often preventable illnesses. The various causes range from industrial accidents and true organic symptoms, including cancer, heart disease, to mentally induced illnesses including nervous or mental breakdowns, and accidents resulting from accident proneness and hypochondria. It is here that medical departments are of invaluable service in correctly diagnosing the problem, recognizing the symptoms and getting to the root of the trouble in the shortest period of time so that lost time due to illness is kept to a minimum.

INDUSTRIAL MENTAL PROBLEMS

Because of the intimate connection between mental health and industrial adjustment, there are many areas where a medical department contributes to better human relations. The medical department normally maintains an attitude of cordial and of individual attention to each patient regardless of pressure of time and number of patients; for one of the big problems of industry is the employe's loss of identity and individuality due to size of companies.

Where the medical department has been unable to utilize its fullest capabilities, part of the fault has been with management and part with the personnel departments who lacked a real understanding of the necessity of integrating activities of each department. Management's main difficulty has been its failure to recognize that behavior and attitude are largely shaped by person-to-person and day-to-day relationships.

Many of these relationships are between the supervisor and the employe. Also many plant managers take the position that matters affecting the emotional stability of an employe are personal views of the employe and should not be of any concern to the company.

Studying the Individual. Industrial hygiene has been developed to protect and promote the physical and mental health of workers. This is the concept which regards health as a positive condition rather than the mere negation of disease. It studies the individual as a human being and considers his personality, background, and environment in relation to his symptoms and illnesses.

In the sphere of psychosomatic medicine, the medical profession has achieved much in industry in defining the functional history of emotional ill health, frustration, and disappointment. It has succeeded in pointing out the cumulative effect of these factors in causing physical and mental breakdown, accident proneness, and repeating illnesses; in pointing out that the work situation is all important in determining personal mental health, and in demonstrating the casual connection between interpersonal stress and labor management problems.

When we speak of "mental health," however, just what do we mean? Basically it can be defined as that state of mind which enables one to meet and cope with everyday problems. Mental hygiene considers the degree and quality of intelligence a worker possesses in relation to his work situation. It also:

1. Studies the individual's capacity for growth
2. Studies the personality factors involved in an industrial environment, and the mental mechanisms to find out why people act the way they do
3. Studies the strains imposed by particular jobs and estimates the maximum stress an individual can take
4. Seeks to understand the em-employe as an individual.

If properly applied, mental hygiene can relieve much industrial stress caused by the mentally ill, the psychoneurotic, the alcoholic and chronically maladjusted individuals. However, it is important to recognize that the aim of all counselling and psychotherapy in industry is normally limited to aid an employe in adjusting to his industrial duties, and not to reconstruct his personality.

Role In Industry. The aim of industrial health relating to mental health is not specifically to assist the abnormal person, but rather as a counselling service, which through proper selection and placement attempts to maintain the good mental health of employees. It also assists those who, because of personal problems, are experiencing difficulties in adjusting to the industrial environment.

There are very few formal mental hygiene programs in industry today. Inasmuch as the field of industrial psychology is relatively new in terms of years, it has just begun to show industry the important role it plays in production efficiency, reduced turnover and labor problems.

One company who has tried such a plan was the Caterpillar Tractor Co., Peoria, Ill. In 1944 a program was initiated to direct attention to all phases of behavior which affect mental health. This program represented the experience, observations and research in industrial mental hygiene of the Caterpillar Tractor Co. and the Cornwall University Medical College. Its aim was to improve human relations in the organization by improving selection and placement techniques, and to counsel employes with minor emotional and personality problems. It was also designed to instruct supervisory personnel on how to deal effectively with employes and their emotional disturbance so that good work attitudes could be maintained.

Personality and Illness. Personality disturbances of a worker will lower his productivity. They cause reduced working efficiency and frequent absenteeism. It has been shown that the degree of disability from illness is closely related to the personality patterns, that the frequency of absenteeism is not only closely related to the personality pattern, but is markedly influenced by the worker's morale.

The monetary loss in industry due to emotional maladjustment is probably greater than that caused by more commonly recognized factors—this seems to be true of departments as a whole as well as individual employes. Departments with reputations of being smooth running and with employes well adjusted and efficient have lower rates of absenteeism. Also, employes in less efficient departments frequently show signs of emotional disturbances, are late for work, have frequent medical absences, and are sent to the medical department more often for advice and treatment.

Industrial Physician. The industrial physician makes it his business to be acquainted with personnel practices and procedures. He is well aware of the problems caused by industrial stress and strain and emotional factors related to the worker's environment. He is not only interested in repairing industrial injuries but also in preventative medicine. His object is generally to help the company's over-all industrial program by assisting employes with medical service or advice and cooperating with management on all medical problems.

Since maximum production is the first requisite of a successful business, healthy employes are one of the greatest assets any organization can have. Absenteeism and impaired efficiency resulting from ill health are costly to both the employer and employe.

The sociologic problem of industrial medicine is that illness is viewed in different and sometimes conflicting ways. To the supervisor, illness is an unforeseen interruption of his production schedule. To the plant physician, it is the illness of an individual; but the question of health must be related to his employment duties.

The link between health and employment can create tension between the physician and the supervisor, or the physician and the worker if not handled properly. The employe will consider the physician a management man with a certain degree of implied authority, and as a result may feel that any medical decisions will be toward management's side. On the other hand, the supervisor might feel that a medical department recommendation is helping the employe procrastinate. For this reason much tact is needed.

INDUSTRIAL INJURY

Some accidents are machine made, others are man made. The first group includes accidents arising from de-

fects in machinery and material, and requires the attention of the safety and industrial engineer. The second group comes from defects in man himself—errors in judgment, defective coordination or unstable emotional control.

Everywhere in an industrial plant where there are moving vehicles, automatic machines with cutting and compressing parts, uneven and slippery floors, there will be injuries to the unwary. It is necessary to be alert and skillful to avoid injury. Therefore, those who are handicapped by an impairment of the central nervous system are more likely to have injuries unless they overcompensate by care.

Avoid Neurotic Complications. The feeling of the worker in relation to his injury is a very important factor to consider. Under present compensation laws and legal procedures, the suggestion is often made to the individual that he is more severely injured than he actually is. Thus, he fastens to this suggestion and believes it to be fact. For this reason it is important that an accurate diagnosis be made as soon as possible before resulting neurotic complications develop.

There is also the possibility that a long, persistent neurosis can develop as the result of an injured worker's listening in the courtroom or commission to all the arguments of his case. From what he hears, the worker builds up in his mind the possibilities to which he may unconsciously react. When this happens, it takes a "favorable" verdict to cure him psychologically.

There is a possibility in cases such as these that hysteria will develop. It is difficult to ever clearly distinguish hysteria from malingering. The worker may have an unconscious idea of his illness, and find himself in a safe position, may malinger; and if allowed to continue for an indefinite period, may result in the worker's actual belief in his malingering. Thus, he automatically reverts to becoming hysterical again.

This is why the question as to whether payments spread over a period of time for an industrial accident are feasible. It may be better to award a lump sum on industrial compensation cases rather than continued disability payment, so that recovery can be greatly hastened.

PREVENTIVE MEDICINE

An important function of industrial medicine is in the field of preventive medicine which has aided the growth of industry. Industry has an obligation from both a social and economical view to preserve and improve the health of the people who make up its community.

Industry has already accomplished a great deal in the way of preventive medicine in the last 40 years. One result has been that although the nationwide toll from accidents has increased, the proportion of accidents in industry has steadily fallen.

A second major contribution to preventive medicine which industry has made is in the field which concerns itself with the supervision of the working environment, health education, and counseling. The potentials of industrial medicine, however, have scarcely been tapped.

Handling Accidents. An example of what has been done is the experience of the Third Avenue Transit System in New York. By treating accidents as a medical problem, this organizations which employes 2,000 bus operators, cut its annual accident total to less than half and saved hundreds of thousands of dollars in compensation and liability.

There are many other areas in which preventive medicine can be effective by reducing accidents, absenteeism, labor turnover, and workmen's compensation premium. It also improves personnel and labor relations, morale, public and community relations, and secures and holds desirable employes.

Most companies do something in the field of preventive medicine even if it is only providing workmen's compensation insurance as required by law. Other firms have simple clinics, physicians on retainer basis, or complete medical services with clinics having fully equipped examination rooms, operating rooms, dental facilities with a part or full-time dentist available for preliminary examinations and recommendations.

Mental Health. Setting up preventive measures in the field of mental health is much more difficult and complicated than setting up such measures for physical health. The mental health problem is so complicated that it is hard to deal with it simply. Probably the most important places to begin work in mental hygiene, however, are at home, school, and in the industrial environment.

In counseling a worker, one must think of all the complicated problems of special interests, ambitions, family bonds, feelings of superiority, of aggression and submission, of hostility and resentment. The life of the worker outside his employment situation may determine his success or failure. That is one of the many reasons that a preventive mental health program is so difficult to develop.

The Role of Insurance. Very little consideration is ever given medical or sickness disability insurance as one technique of preventive medicine. However, when payment of hospital and medical bills are guaranteed through insurance, one of the most important causes of delay in seeking medical care has been removed.

A great many companies today participate in providing some form of medical insurance and paid sick leave when employes become temporarily disabled as a result of non-occupational illness. The insurance may cover hospital bills and other medical expenses, or it may carry a cash indemnity to assist the sick employe in meeting his medical and living expenses while he is ill.

Some states have enacted sickness disability laws which call for compulsory insurance to provide cash indemnity benefits to employed persons temporarily unemployed because of non-occupational illness. Under some of these laws industry may be held responsible for a substantial share of the premium payments, while in others the employe pays the entire amount.

PHYSICALLY IMPAIRED WORKER

Although much has been written in medical periodicals concerning the physically impaired worker, too little attention has been given understanding him by the personnel or industrial relations departments. Although handicapped have always been employed, much of this has been in large organizations where special studies were made to fit them in specialized situations. The organizations who promoted the use of the physically handicapped made slow headway until World War II when as an aftermath, a great many veterans were discharged with physical

impairments. Many of these, however, were capable of performing a day's work and thus entered the employment market to become gainfully employed.

The war also created a shortage of manpower, and as a result the physically handicapped were tried wherever possible to fill the void in labor ranks. During this period many systems for selective placement of persons with physical impairments were utilized. These systems varied in technique, but all embodied an analysis of the job for physical requirements, evaluation of physical capacity, and matched the two.

The Job and The Man. Examination of a human being to find work for which he is fitted calls for knowledge of a method not yet possessed by medical science. This is a method which will measure the will to succeed and also estimate human reserve compensation. The present techniques of measuring job requirements and physical capacities are only reasonable guides. One explanation of individual variations in reserve compensation is possibly found in the will to do, which in turn is often influenced by incentive difficult to discover and impossible to measure. As a result absolute quantitative estimates of the working capacity of a human being are almost impossible. That is why periodic examinations of the handicapped employe and the job are so important.

Because the employment and study of physically impaired workers in industry has not been developed as fully, there exists a basic fear and lack of understanding of the capacity and abilities of the impaired worker. An employer takes a big risk when he hires a seemingly normal person without measuring the large number of factors involved. Most often he does not consider that it may exceed any risk taken with physically impaired persons whose capabilities have been evaluated and matched with the requirements of the job.

Mistakes in placing workers with an impairment can happen, as in the case of physically capable individuals. But this should not prejudice an employer against considering another person with the same defect for the same job unless it has been definitely established that there is a physiological or psychological restraint in the requirement of the job.

Work Records. Dr. H. A. Vonachen, Medical Director of Caterpillar Tractor Co., says that on the basis of an eight-months' survey done by them for the government, it was found that the average handicapped person's productivity was equal to that of a normal individual. Those below normal production were in the unskilled group and with further training might have shown better results, as all the handicapped employes had been unskilled at the start. The accident rate was less than for normal persons, which probably resulted from the usual caution shown by handicapped persons, plus proper placement and stressing of safety.

Another study of physically impaired workers in industry[1] found that generally speaking, their efficiency and productivity was generally on a par with the unimpaired, when properly placed. Also, a smaller percentage of the impaired people were discharged or laid off; a smaller percentage terminated because of absenteeism; and a smaller percentage stopped work because of living conditions, domestic conditions, working conditions, or getting other jobs; and most surprisingly a smaller percentage stopped because of health.

One of the biggest difficulties with the handicapped is their reluctance to fully recognize their limitations. Education on this point is very important.

WHO ARE PHYSICALLY IMPAIRED?

There is always the question of who are the physically handicapped. The term usually covers:

1. A small number who are physically unable to work at all

2. About 23 million individuals, including veterans, who have lost their basic skills through accident and illness and need rehabilitation, counseling, or training before they will again be ready for suitable employment

3. The large group of physically handicapped who possess skills, but require assistance in obtaining employment

4. The millions of workers whose physical limitations require consideration if they are to be successfully placed with safety to themselves and others

5. Those who visit doctor's offices and hospitals because of physical difficulties.

From a strictly medical point of view, however, all are physically limited to some degree who do not possess the capacities to meet the physical requirements of the most arduous job. From this standpoint, the physically limited person is the average worker, and the fully able bodied individual is the exception. This then raises the question as to what is the difference between the "physically handicapped" and the "occupationally handicapped." The first term refers to all those, including the psychoneurotic, who do not possess full physical and emotional capacities; while the occupationally handicapped refers to workers' lack of ability to fill all the requirements of a particular job.

A physical handicap remains a physical handicap whether or not it prevents employment in an occupation; it becomes an occupational handicap, however, only when it is the direct cause of preventing one from getting a job.

In Conclusion. Management's interest in the health of the worker should begin with the pre-employment examination and not end until the worker retires. The effectiveness of the individual worker is directly related to his health, which in turn is an expression of his individual medical supervision and care.

The curative technique can never adequately solve the health needs of people. A preventive approach is also necessary.

The objective of a proper industrial health program is to:

1. Ascertain by examination the physical and mental fitness of employes for work

2. Maintain and improve the health and efficiency of those employed

3. Educate workers in accident prevention and personal hygiene

4. Reduce lost time and absenteeism from illness or injury.

Many of the problems that arise because of mental conflicts or maladjustments in the industrial group can be solved or at least alleviated, by proper application of human understanding.

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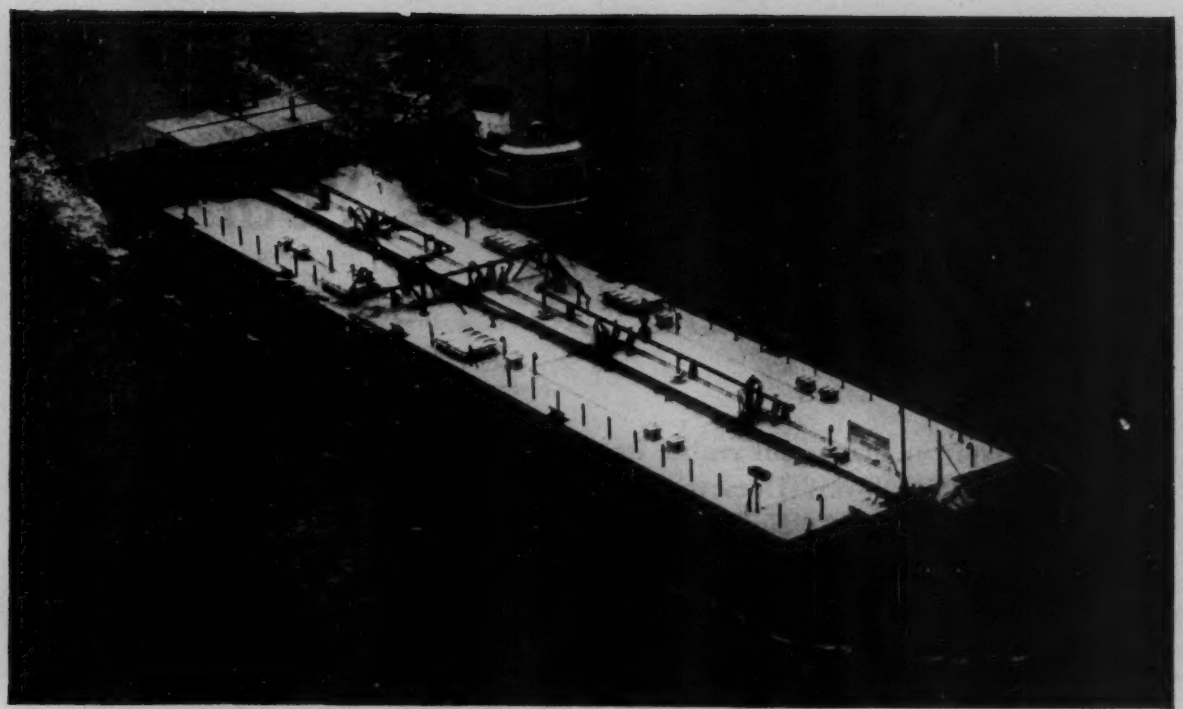

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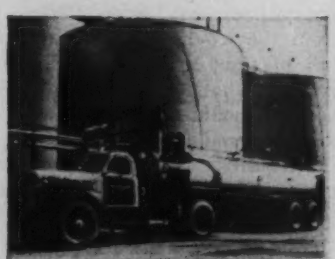

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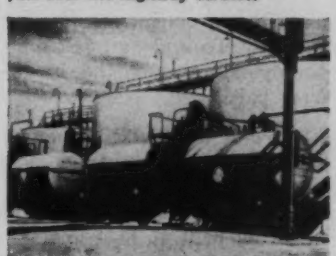

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How Professional Is Your Management?

Does your management realize its obligations to its technical employes? Does your management encourage professionalism? A "No" answer to either of these is good news to Walter Reuther and the 50,000 engineers and scientists who have already joined a professional union

John J. McKetta, The University of Texas
Austin

THE YOUNG PROFESSIONAL reads with interest the various articles on "What Management Expects from the Young Professional Man." The literature is full of these articles wherein various experts tell our young'n what he should do to progress in the industry, how he should act, how to work hard, how to love his neighbor, and so forth. These writers list the many qualities required of the young professional man in order for management to accept him as a member of its "team."

But on the other side of the ledger, there is a dearth of articles telling management how to treat the young professionals it already has on its technical staff. In your own case, for instance, is your management cognizant of its obligations to you—one of its technical employes? To find out, just grab your pencil and rate your management on the 20 items in the quiz on the facing page.

Is There A Conflict? This quiz brings out many areas which could be considered by a management which wants to better relations with its technical professional personnel. Seemingly, however, management is complacent—content to sit back and feel its relation with technical people is the very best.

The results of a study released recently by the Opinion Research Corporation, Princeton, N. J., however, show that there is a basic conflict between management and professional engineers and scientists (see Box 2 and 3 for definition of "management" and "professionalism"). Of the engineers and scientists interviewed 71 percent felt that management misuses the technical employe's job talents, while 80 percent felt they were underpaid when compared with others with similar background. There were many other points of consideration but this study does establish that there is a conflict between management and its professional employes.

What Should Management Do? Now, we know that professionalism, as defined in Box 3, is an individual characteristic and it is up to each individual to maintain his professional standards. At the same time, however, management must be professionally minded enough to provide an atmosphere which will encourage professionalism.

The most important requirement, of course, is for management to make its technical employe feel important and necessary to the company and to its activities. Each member of the management team should read and practice the suggestions of S. G. Henry's excellent article, "The Fine Art of Human Relations."[1] Management can purchase technical manpower, but management cannot buy *esprit de corps!* Management must earn this.

Management must definitely recognize that engineers and scientists are professional employes and as such should be distinguished from technicians, in duties as well as salaries. This should be in the same manner as the physician is distinguished from the nurse and medical technician.

It is equally important that management establish a policy of demanding top level work from each professional employe; firing those employes who do not maintain professional progress, abilities and interests, or shifting them to non-professional jobs with non-professional titles.

What Could Happen? It seems to many technical men that management has but one goal in mind—to make money for the stockholders. Indeed, this is quite admirable, but many times this goal is sought so ruthlessly that management seems to have neither the time nor the in-

How Does Your Management Treat The Professional Engineer and Scientist?

Yes No

I. SALARY

☐ ☐ 1. Does your management tie salary increases to merit of work?

☐ ☐ 2. Does your management give you a good explanation of pay rate structures?

☐ ☐ 3. Does your management hire new technical graduates at salaries similar to those of older technical employes?

II. ASSIGNMENTS

☐ ☐ 4. Does your management provide tasks with greater challenge, particularly to individual employes?

☐ ☐ 5. Does your management provide opportunity to carry research and design jobs into actual operation?

☐ ☐ 6. Does your management ask report writing on routine matters and on "dead end" assignments?

III. PROFESSIONAL GROWTH

☐ ☐ 7. Does your management provide adequate contact for you with other experts in the field such as technical speakers, consultants, etc?

☐ ☐ 8. Does your management provide opportunity for you to attend professional meetings of your professional society in distance locations at least once a year?

☐ ☐ 9. Does your management encourage you to write and present good papers for your technical society meetings?

☐ ☐ 10. Does your management encourage you to publish good technical material if the information does not disclose pertinent company trade secrets?

☐ ☐ 11. Does your management give you an opportunity to do creative work?

IV. OTHER POINTS

☐ ☐ 12. Does your management have a complete explanation of company policies and procedures available for your review?

Yes No

☐ ☐ 13. Does your management provide means to minimize routine work for professional employes?

☐ ☐ 14. Does your management recognize engineers and scientists as professionals?

☐ ☐ 15. Does your management give you better recognition if you are a member of your professional society?

☐ ☐ 16. Does your management minimize regimentation?

☐ ☐ 17. Does your management credit individuals who do the job rather than the man who carries the news?

☐ ☐ 18. Does your management retain incompetent engineers and scientists in sub-professional jobs and still retain the titles of engineers or scientists?

☐ ☐ 19. Does your management provide adequate desks, office space, secretarial assistance, dictaphones, telephones and other necessities for your work?

☐ ☐ 20. Have you ever shaken hands with the president of your company?

GRADING: Give your management 5 points for each answer of "no" to questions 3, 6, and 18. Give 5 points for each answer of "yes" to the other 17 questions. Maximum is 100 points.

RATING:

90 - 100	Superior
80 - 90	Excellent
70 - 80	Good
60 - 70	Passing
50 - 60	Let management read this
0 - 50*	Change companies

* Remember that you *may* have rated your management low because of your own attitude. Regardless of the fault you should change companies because if you rate your management this low it is better for both of you to change partners.

NOTE: Let's be fair about this quiz. If your management rated 70 or above don't you think your management would appreciate a note from you telling of its grade on this quiz?

Who is Management?

There is a trite statement that "every technical man is management." Haven't you discussed a problem with your group leader only to hear him say, "Our management thinks that . . ." In fact go a few steps higher to one of your vice presidents and you may hear him say, "Our management feels that . . ." In this paper, management is that policy making group which generally consists of the president, board members and chairman of the board.

What is Professionalism?*

Professionalism is defined many ways but the definition that is meanful to me is the one which includes the "doing more than is assigned to and expected of an individual" and which also includes ministration to humanity. No one, in my opinion, has defined professionalism better than the late Dr. W. E. Wickenden, President of Case Institute until his death. In his "Second Mile," Dr. Wickenden took his text from the Sermon on the Mount, "Whosoever shall compel you to go one mile—go with him twain." He then went on to say:

"Every calling has its mile of compulsion, its daily round of tasks and duties, its standard of honest craftsmanship, its code of man-to-man relations, which one must cover if he is to survive. *Beyond that lies the mile of voluntary effort*, where men strive for excellence, give unrequited service to the common good, and seek to invest their work with a wide and enduring significance. It is only in this second mile that a calling may attain to the dignity and the distinction of a profession."

clination to worry with problems which are not obstructions to that goal.

Obstructions take many forms, but certainly one of the most formidable is the labor union, and the many headaches which these unions cause management. For this reason it is difficult for technical men to understand why management has not yet come to the full realization that technical men may someday have to resort to this same type of organization in order to receive management's full consideration. This is particularly true in view of the fact that 50,000 men have already taken the professional union route because most felt their professional societies had no positive plan for improving professional status.

In spite of this evidence, however, many managements appear quite unconcerned with the possibility of having to bargain collectively with technical men. They seem oblivious to the fact that the growth of professional unions will greatly stifle efforts of the individual technical man, the company, and our entire national effort.

Perhaps though, this great void of management indifference can be attributed to the feeling that labor unions (as we know them today) will not actively seek to organize white collar technical professional men. For those who are either so uninformed or misinformed, read these words of Walter Reuther, top man in the UAW who said, just in December, 1959, that organization of engineers, scientists, technicians and office workers is the "most essential organizing task facing the trade union movement."

A "Recognized Company" List? Most of the professional societies have a committee on the ethical behavior of the professional member. A member may be expelled from his respective society for a breach of ethical conduct. Some members feel this is a one way street and that some of the companies should also be admonished for seemingly unethical actions. For example what would be wrong with some major inclusive society, such as EJC or NSPE, preparing a list of all "recognized" companies who employ technical men? In the case of an unethical action on the part of the company, the company would be removed from the "recognized" listing until the management proved deserving of such reconsideration.

It is true the problem of setting up such a list, and of maintaining it would be an enormous task. It is also true that the whole idea may sound somewhat naive. However, such action may make many companies review their hiring and employe relation policies so that they are not faced with the situation of firing hundreds of engineers at one fell swoop—as happened recently within a month of a so-called "engineering shortage."

About the Author

John J. McKetta is chairman of the Chemical Engineering department at The University of Texas. A member of numerous professional societies in his field, and active on many national committees, he is a national director of AIChE, member of the board of regents of Tri-State College, member of the board of directors of five companies, and is an active consulting engineer. Dr. McKetta is chairman of the editorial committee of PETROLEUM REFINER, and was its editorial director from 1952-54. He has written more than 50 technical articles, many chapters in various technical books, and is co-author with Dr. K. A. Kobe of an outstanding series of books on "Advances in Petroleum Chemistry and Refining." He has a B.S. degree in chemical engineering from Tri-State College, and M.S., and Ph.D. degrees from the University of Michigan, and both schools have honored him with the title "Distinguished Alumnus." Dr. McKetta spent five years with Wyandotte Chemical Co. in the Technical Service division, and as superintendent of the Caustic Soda division. He was chemical director of the C. B. Schneible Co. before pursuing graduate studies, and is a registered professional engineer in Texas and Michigan.

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How Well Do You Supervise?

A good supervisor will know the limits of his authority and responsbility—and the difference between them

J. E. Bigham
Chemstrand Corporation
Pensacola, Fla.

IF I WERE to choose between having my authority defined or my responsibility outlined, I would choose—without hesitation—responsibility. Even then, I would prefer that no rigid lines be drawn, but that I be allowed to accept broadened responsibilities as I grow with my job.

To establish a common ground for discussion, let's identify some phases of responsibility and take a look at the general scope of authority. Each supervisor's responsibilities depend upon his position and his company. Most members of supervision know what their responsibilities are, but I doubt if most know the full importance of those responsibilities. For a general discussion, therefore, we might say that responsibilities usually include:

1. Specific job functions which fall under one's leadership
2. Personnel performance, attitude and behavior
3. Communications—multi-directional
4. Assistance to and from others
5. Loyalty.

Very seldom is a supervisor's authority specifically designated. In industry, authority is implied and is derived from a supervisor's responsibility. Management exhibits its confidence in a supervisor by designating his functions. He is instructed in plant practices and procedures and is made familiar with organizational guides and personnel policies. Management then expects this supervisor to use his initiative and judgment in performing his responsibilities. By this, he derives his authority.

Thus, a supervisor can measure his authority by:

1. The extent with which he may deal with others
2. His scope in committing company funds, manpower or facilities
3. His prerogative in determining accounting of costs
4. Expenditures he originates, approves, or recommends
5. The flexibility he may apply to practices and procedures
6. His freedom in placement of personnel within his organization
7. His applications and limits of discipline.

RESPONSIBILITY

As mentioned, a supervisor's job functions are usually designated and rather clearly defined although some would prefer that they be exactly defined. Therefore, in order to properly complete performance in one category, it is often necessary to make sure that preliminary or adjacent jobs are correctly performed. That you are your brother's keeper is an implied responsibility; this doesn't mean being critical of groups you work with, but it does call for contributory intelligence. An example of implied responsibility could be as follows:

You are a supervisor in charge of a fabricating crew and receive a work order to fabricate an item. With the order you receive a set of prints and an estimated cost for material and labor. Your responsibility is not just to fabricate that item! My contention is, you are responsible for evaluating the prints, for noting that the materials specified meet company's standards, and for assuring yourself that the estimate is sound. If I were your management, your maintaining responsibility for only

the fabrication would be a poor excuse if:

1. The final product did not fit together because the drawing dimensions were in error
2. Weak material would endanger lives
3. You knew you would have to spend three times the funds approved for expenditure.

True, other supervisors should have caught the errors and should have known better than to make a low estimate. But this does not excuse you for contributing to poor practices.

Working With Others. Personnel relationship is probably the most important responsibility of a supervisor —important to his company, his personnel, and to himself. A supervisor is measured by the quality and quantity of the work he gets done. If he can provide an organization with an atmosphere conducive to cooperation and individual initiative, he will be recognized. If he has the common decency to give others credit for their initiative, he will reap even greater benefits.

His responsibility includes delegating his responsibility. Understand, I have said delegating responsibility —not his accountability. This can be neither delegated nor assigned. If a supervisor trains assistants, determines and develops the abilities of others and trusts them to fulfill their obligations, his own output will be magnified. Results are obtained by working through people; by leading, not driving. Performance depends upon attitude.

Most workers' attitudes will reflect the attitude of their supervisor. A smile is not the only thing that is catching. A supervisor is responsible for learning the reasons behind policies, procedures and practices, because only when he understands them will he be in a position to truly accept them. Then when he accepts them himself, he can convince others of their importance. Convincing others breeds good attitudes, and a good attitude makes for a good product. A poor attitude can lead only to corrective discipline.

Discipline. Discipline itself is a responsibility. Corrective discipline is only a small part and is that portion hardest to apply. I am afraid that too many supervisors feel that discipline is a power of authority. I often wonder what disciplinary measures they would use if they had such authority.

Many associate hiring and firing too closely with discipline. They don't realize that hiring is a privilege, while firing is a chore. Basically discipline is the product of recognizing and understanding the individual importance of each worker, the mutual confidence between the worker and his supervision, and the fair application of policies and procedures. Remember, a well disciplined group is a well-behaved group, not a well-whipped group.

Communications. Another prime responsibility for supervisors lies in the area of communications. The extent of communications for some supervisors is telling their workers what the boss said. For others it is telling the boss what the workers said. Often when something is good for the worker, the supervisor says, "This is the way I want you to do it." When it is unpleasant, he might be heard saying, "This is the way the boss wants it done."

Communications is not just talking. Good communications can consist of good listening and really hearing what is said. Sometimes it even includes seeing what is said by the expression or the inflection applied. Good communications results from training yourself in two ways. The first is to make sure you know what you want to say before you say it, and the second is to understand what really has been said when you hear it.

Another point is that a supervisor must know as much about his workers and his management as is possible. Only by knowing their individual background and experience will he be able to interpret from one and reinterpret to the other whose background and experience is of course, much different. Here, however, he also must realize that when he is interpreting and relating facts from one group to another, he is greatly influenced by his own experience and background.

Mutual Assistance. Communication is also a means of gving and receiving assistance. A supervisor is responsible to many persons in the company, and as a result, the services of his group must be available to any other group having need for such services. By giving such service, a group can gain recognition, for to be recognized, others must know you. If you think your group can do things, then don't pass up the opportunity to do them. It doesn't even hurt to create a few opportunities.

Another way that a supervisor can be helpful is by realizing the limitations of his group in certain fields and by relying on others for the assistance required to do a job properly. No one person, nor any one group, can be expected to know the millions and millions of things that are to be known. In other words, each supervisor is responsible to his management to make his abilities available to the entire organization, and to utilize the special abilities of others within the organization.

To serve is one way of being loyal. Sometimes it is the only way an individual is loyal. It isn't uncommon to hear one say, "I do my work, what are they griping about?" With a supervisor, just doing his work isn't even a good start. A supervisor has the responsibility of being loyal to his company, his personnel, and himself. In fact, the greater his responsibilties, the higher are the demands upon his loyalty.

AUTHORITY

Let's briefly look at your authority. Do you talk with others and reach decisions concerning your work without getting someone else's approval? The extent to which you may make decisions and have them accepted by others is a measure of your authority. Most supervisors work out highly important details between their groups without consulting higher management. This is authority.

Do you sign requisitions for equipment or materials? Can your signature authorize withdrawals from your company stores stock? Can you move men from one job to another? These are measures of your authority.

How Far? When you consult with individuals inside or outside of your company, you do so with knowledge of how far you can commit your company, your department or your-

self. This knowledge denotes an understanding of your authority in each individual situation. I could not, from knowing your job, tell you what your authority would be. I contend only that you know what your authority is if you will analyze your decisions and actions. Quite often you do not have a particular authority just because you don't exercise it.

When you are given responsibilities you are expected to have some initiative in carrying out those responsibilities. If you will exercise this initiative with good judgment, I believe you will find you possess all the authority you need, and what would you do with more authority if you don't need it?

Did you ever excuse anyone for making a mistake? Have you forgiven a trespass by a worker? Upon doing so, you exercise authority. If it was not within your authority, then you had no right to do so.

Do you recognize the will of your superior? I believe that if he were to suggest something be done, and it was proper to do it, you would make an effort to bring about its completion. By doing so, you have recognized his authority. Thus, by analyzing the effect of your will upon others, you might also get a measure of your authority. This leads me to believe that authority is quite related to influence and guiding.

Responsibility vs. Authority. Authority is a changeable thing. Responsibility, nevertheless, exists whether you have approved authority or not. Let's look at an example: Consider a hypothetical company which consists of an Engineering department, a Production department and a Technical department. The responsibility of each depart ment is very well defined. The Production department is to produce in quantity and per quality specified, the Technical department is to develop new and improved qualities, and the Engineering department is responsible for efficient spending of money on equipment. These are their responsibilities and each department supposedly has the authority to carry out those responsibilities.

Let's say the market is good, sales are high, and the product is competitive. The operating equipment becomes worn and production begins to fall off, but the only vendor that can supply replacement equipment rapidly wants the highest price. Production needs the equipment to produce but Engineering wants to buy a slower delivery item to efficiently invest company funds. I believe that higher management would decide to pay more and get quicker delivery. However, it is still the responsibility of the Engineering department to point out the inefficient investment, but in this case, its authority is superseded by the Production department's authority to produce.

At the same time, the Technical wants to invest in new equipment to improve quality. To do so, operating equipment would have to be shutdown for replacement. It is Technical's responsibility to improve quality, but I suspect that under the existing circumstances, Production's authority to produce would again prevail.

Be Flexible. What I intend to show is that authority must be flexibly applied in its final concept. Just because your management may decide against allowing you to exercise your authority completely does not mean they have repealed it, nor are they rebuking you. It means simply that under the conditions existing, based on the facts at hand, and because of their greater responsibility, they are exercising authority to reap the greatest company benefit. Remember though, this does not subtract one bit from your responsibility. You are still expected to present sound arguments, a firm defense, and positive facts on each and every occasion.

You can probably think of "I told you so" instances. No doubt your management people remember them too. If they made mistakes in not deciding your way, it could have been for several reasons. The other group presented better arguments, your dependability may not have been established as firmly, or a need for saving time or initial investment may have weighed heavily upon them. Don't ever say, even to yourself, "I told you so." Just prepare better arguments, rest assured your dependability is better known for your having been right, and always strive for real savings in time and capital.

In Conclusion. More important than the amount of responsibility you have is the way you perform these responsibilities. More important than your authority is your ability to apply it. But you should attempt to spread some of your responsibility. Determine the potential of your workers; assist them, and train them for greater potential. Give each one responsibility so that he will know that he is important and feels needed.

Discuss your progress and your methods with your personnel. Never be satisfied with your organization. Make it a laboratory and keep testing. Encourage each individual to use his initiative and expect him to have ideas.

A few ideals won't hurt anything either. I wouldn't care for a department full of conformists, without creative ideas. You have authority to show appreciation and give credit, as well as call attention to expecting better. If your personnel are under confident and feel insecure, then examine your approach; it may be that you have been making some arbitrary decisions. Recognize the dignity of man and treat each person as the individual he is. ##

About the Author

James E. Bigham is an instrument superintendent for Chemstrand Corp., Pensacola, Fla. He supervises instrument engineering and maintenance and provides services to the Pensacola nylon plant through the design, development, installation, and maintenance of instrumentation. Holder of a B.S. degree in electrical engineering from The University of Texas, Bigham has been in the instrumentation field since 1941. His experience includes electrical, aircraft, and industrial control systems.

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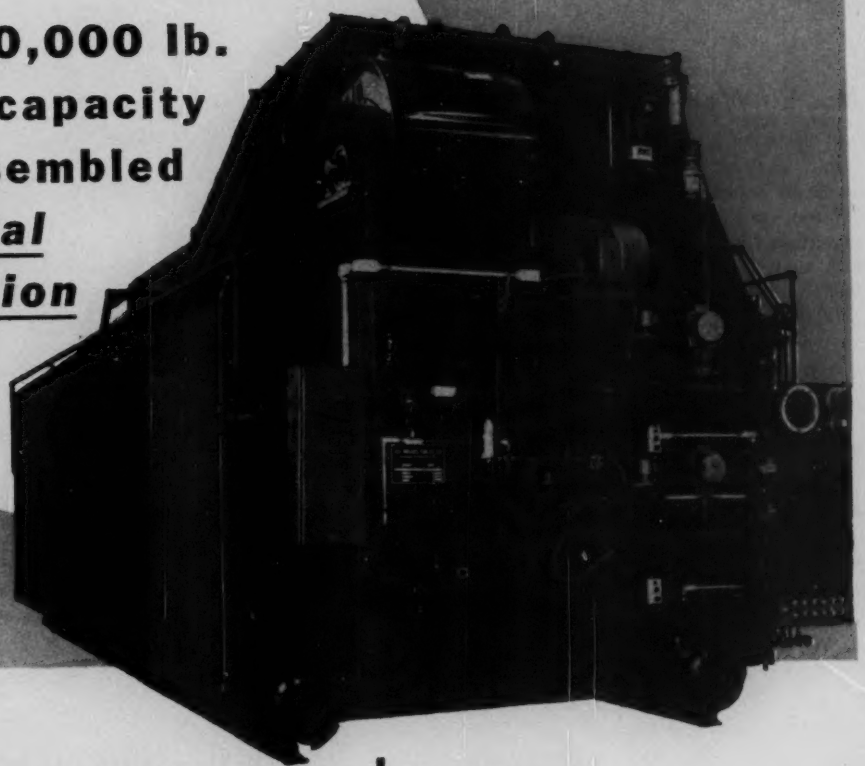


Wickes Type A units are of simple design, ruggedly constructed and adaptable to a variety of operating conditions and may be fired with oil, gas or combination of both.

All units are shipped completely shop-assembled including superheater, fuel burning equipment, safety and combustion controls, forced draft fan and drive, soot blowers and feedwater regulator.

Save on

- First Cost
- Operating Expense
- Space
- Delivery Time
- Installation Time

For more detailed information on Wickes Type-A steam boilers, write for our catalog 56-1. Bulletin 55-1 covers the complete line of Wickes Products and Facilities.

WICKES type A

WICKES

WICKES BOILER CO., SAGINAW 18, MICHIGAN

DIVISION OF THE WICKES CORPORATION

RECOGNIZED QUALITY SINCE 1854 • *SALES OFFICES:* Boston • Chicago • Cleveland • Dallas • Denver • Detroit • Houston • Indianapolis • Los Angeles • Memphis • Milwaukee • New York City • New Orleans • Portland, Ore. • Saginaw • San Francisco • Springfield, Ill. • Tulsa.

169-R

Test Yourself on Labor Relations

No. 1. Workers Sue Customer

A group of maintenance men was assigned to do some repair work at a customer's plant. While they were at work an accident occurred and four of the men were injured—not seriously. They received workmen's compensation for injuries and time lost.

A year and eight months after the accident the four men started a lawsuit against the customer. Each asked $100,000, for personal injuries. A few weeks later the men were fired. The company offered the following reasons:

1. The news of the lawsuit appeared in the local papers and was harmful to the company's reputation.
2. The unfavorable publicity implied that the customer's plant was an unsafe one.
3. The workers showed a lack of proper loyalty.

The employes countered:

1. We didn't cause the unfavorable publicity. The stories about the lawsuit were picked up by the newspapers from court records.
2. We are suing the customer—not our employer. This is not a disloyal act.
3. An employe cannot be fired for taking a legal action. Otherwise employes would be afraid to sue an employer for any kind of wrong.

Test Yourself:

Were the employes RIGHT ☐ WRONG ☐

No. 2. Back to Work

After the strike ended suddenly, 30 workers showed up the next morning ready and willing to go to work. The foreman was unprepared for their return. "It'll take a few hours for me to plan my schedules. Why don't you fellows go home and come back this afternoon?" he said.

This they did. When payday came around they demanded four hours reporting pay. They cited their union contract which said that if a man comes to work and there is no work available he is guaranteed four hours pay.

The company answered: This is no normal situation. Reporting pay applies only on routine operations. These men caught us flatfooted. The strike ended suddenly and we had no time to prepare for them.

Test Yourself:

Was the company RIGHT ☐ WRONG ☐

No. 3. Jailed Employe

The company policy stated that employment "may be terminated if an employe is absent from work for 10 days or more without reasonable cause."

John X was having domestic troubles. He was being charged with non-support and was ordered to pay his wife $50 a week. When he failed to come across he was sentenced to 90 days in the workhouse. The company dropped him from the payroll for being "absent from work for 10 days or more without reasonable cause."

When John got out of jail he showed up at the gate but was refused work. He grieved:

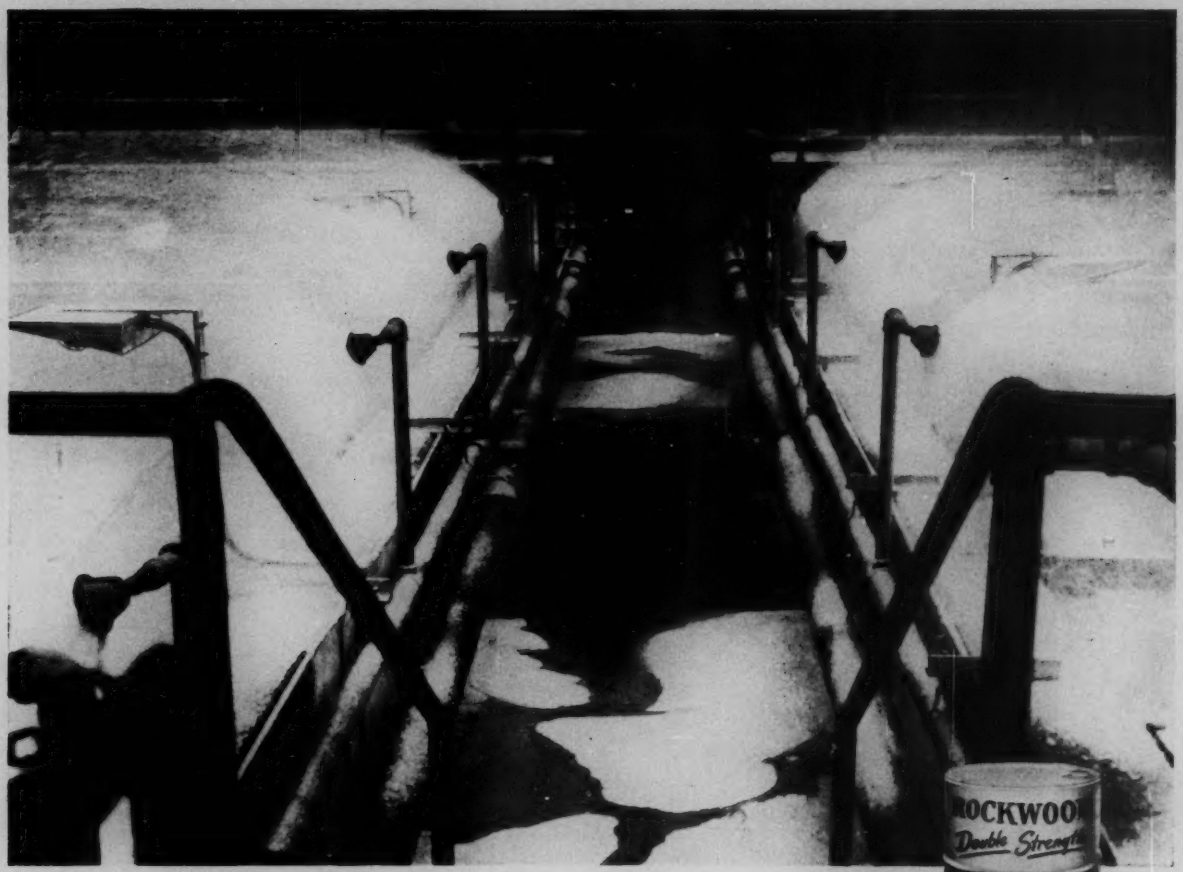
"I was not absent without 'reasonable cause.' I wanted to come to work but I couldn't because I was in jail."

The company answered: You could have stayed out of jail by paying the $50 a week. You chose not to do so and went to jail instead. This was your own doing. Therefore your absence was your own fault. You stay fired.

Test Yourself:

Was the company RIGHT ☐ WRONG ☐

Answers on Page 203



Testing a Rockwood FogFOAM System that guards the oil separator pits in Cincinnati Gas & Electric Co.'s plant.

Here's high protection *against* low flash-point fires!

Double Strength FOAM Liquid Gives Double Protection. Three parts of Rockwood Double Strength FOAM liquid mixed with 97 parts of water and 900 parts of air form a fire-smothering blanket that quickly reseals itself. You pay for only three parts per thousand for this extinguishing agent that has proved its ability to put out spill fires in flammable liquids, with maximum speed and safety for personnel. Tested and listed by Underwriters' Laboratories, Inc. Branch Offices in all principal cities.

In any group of oil separator pits, the pit with the lowest flash point sets the danger mark for the entire area.

To installations of this type — and to many others endangered by fire — Rockwood FOAM and FogFOAM systems bring the surest, most dependable fire protection ever developed.

In the FogFOAM system shown above, protection starts with the heat detectors located around the pits. During any critical temperature rise these detectors sense the inception of fire. The signal is transmitted automatically — and the FogFOAM system goes into instant action.

Rockwood FOAM liquid, mixed with water and air, is then released through many FogFOAM heads over each pit. Within a few seconds a thick blanket of Rockwood FOAM completely covers the threatened area . . . *A disastrous fire has been prevented.*

Fire protection systems are custom engineered by Rockwood to meet the needs of every type of oil and gas installation. Send the coupon for details.

ROCKWOOD SPRINKLER COMPANY

A Division of The Gamewell Company

Engineers Water... to Cut Fire Losses

Distributors in all principal cities

ROCKWOOD SPRINKLER COMPANY
A Division of The Gamewell Company
508 Harlow Street
Worcester 5, Mass.

Please send me information on Rockwood fire-fighting products and systems.

Name.....

Title.....

Company.....

City.....*Zone*..*State*.....

For more data on advertised products, use Readers' Service Cards, last page.

The man who knows how to get ahead (and stay ahead) in business—gets his information and inspiration from the pages of his businesspaper. Nothing else you read is so filled with the news, the facts, the fresh ideas so vital to your success in business as the advertising and editorial pages . . . in your businesspaper.

PHOTO ON LOCATION BY EHRENBERG

Where there's business action, there's a businesspaper

. . . where's there's oil, gas and petrochemical processing business, there's

PETROLEUM REFINER

One of a series of advertisements prepared by the ASSOCIATED BUSINESS PUBLICATONS

New Books...

Refinery Fire Protection

"Fire Protection in Refineries," fourth edition, has been prepared by the Subcommittee on Fire Protection Engineering under the direction of the API Central Committee on Fire Protection. The new publication which replaces the 1941 edition, provides the most recent information on the safe storing, handling and processing of petroleum products.

(API, *Fire Protection in Refineries,* American Petroleum Institute, 1271 Avenue of the Americas, New York 20, N. Y., 26 pages, $1.)

Research Review Summary

"The 1959 Review of Current Research" covers the more than 10,000 research projects underway in 118 leading engineering colleges across the nation. Expenditures on these research activities during 1959 total more than $112 million, according to the figures.

Dean Kurt F. Wendt, College of Engineering, University of Wisconsin, is chairman of the group publishing the book, the Engineering College Research Council, American Society for Engineering Education. Dean Wendt says that these figures are the largest ever compiled in 15 years of council surveys.

The 1959 survey gives complete titles for all projects underway in schools which hold ECRC membership. Numbers of research personnel at each institution are listed, and research policies are summarized. There is a complete index of research project subjects, to help locate activities in similar fields at different institutions.

(ASEE, *The 1959 Review of Current Research,* American Society for Engineering Education, University of Illinois, Urbana, Ill., $2.)

Finding Heat Capacity

"Heat Capacity Determination of Mineral and Synthetic Engine Oils, Lubricants, Fuels, and Hydraulic Fluids in the Temperature Range 75-500° F" discusses heat capacities of 33 mineral and synthetic engine oils, lubricants, fuels, and hydraulic fluids at 80, 185, 290, 393, and 500° F. Calorimeter constants were obtained by internal standardization, eliminating use of a standard liquid. A comparison of latent heats of vaporization of phenyl ether samples is included. The work is a continuation of that described in an initial report, PB 151210, same title and contractor, June 1958, 56 pages, $1.25, released earlier through OTS and still available. The two reports, used together, describe the unique, simple, rapid method used for measuring and calculating heat capacities over a wide temperature range.

(OTS, *Heat Capacity Determination of Mineral and Synthetic Engine Oils, Lubricants, Fuels, and Hydraulic Fluids in the Temperature Range 75-500° F,"* Office of Technical Services, U. S. Department of Commerce, Washington 25, D. C., 64 pages, $1.75.)

Industrial Leadership

"Industrial Leadership" presents as its thesis that management must be greatly concerned with upgrading employes to assume positions of leadership so that a perpetration of free enterprise may be guaranteed. The authors feel that not only management, but American people in general are convinced of the importance of keeping and improving our free economy. Therefore, certain aspects of leadership are common to all phases of human effort—schools, business, industry and government. The authors discuss the challenge of leadership, the need for leaders and the risks they must take, and the effects of many situations upon them. They focus attention on broad principles and generalities and re-examine resources and potentials of leadership in the light of their possible contributions to American business and industry. Questions are provided at the end of each chapter for the use of groups studying the problems of leadership.

(Weber, C. A., and Karnes, J. W., *Industrial Leadership,* Chilton Book Co., Philadelphia 39, Pa., 226 pages, $5.)

Electrical Manhour Manual

"Estimator's Electrical Manhour Manual" is the second in Gulf Publishing Co.'s estimator's library. The scores of manhour tables in this manual were compiled after detailed analysis of many time and method studies . . . covering all phases of electrical installations. The manual shows how to arrive at a composite rate using productivity efficiency and production elements. With the composite rate, manhour estimating can be applied with equal validity to any electrical job, in any location.

The authors (estimators by profession) have found after much comparison on many projects, that production efficiency percentages can be classified into five categories: very low, low, average, very good and excellent. Prduction elements can be grouped into six different listings: general economy, project supervision, labor relations, job conditions, equipment, weather. Using this experience, the authors have devised an accurate and convenient method of estimating direct labor for complete electrical installation for any given system. Thus, by means of this manual, the reader has a dependable method of obtaining a production efficiency percentage by applying all known local conditions and variables . . . plus a method of obtaining a complete direct

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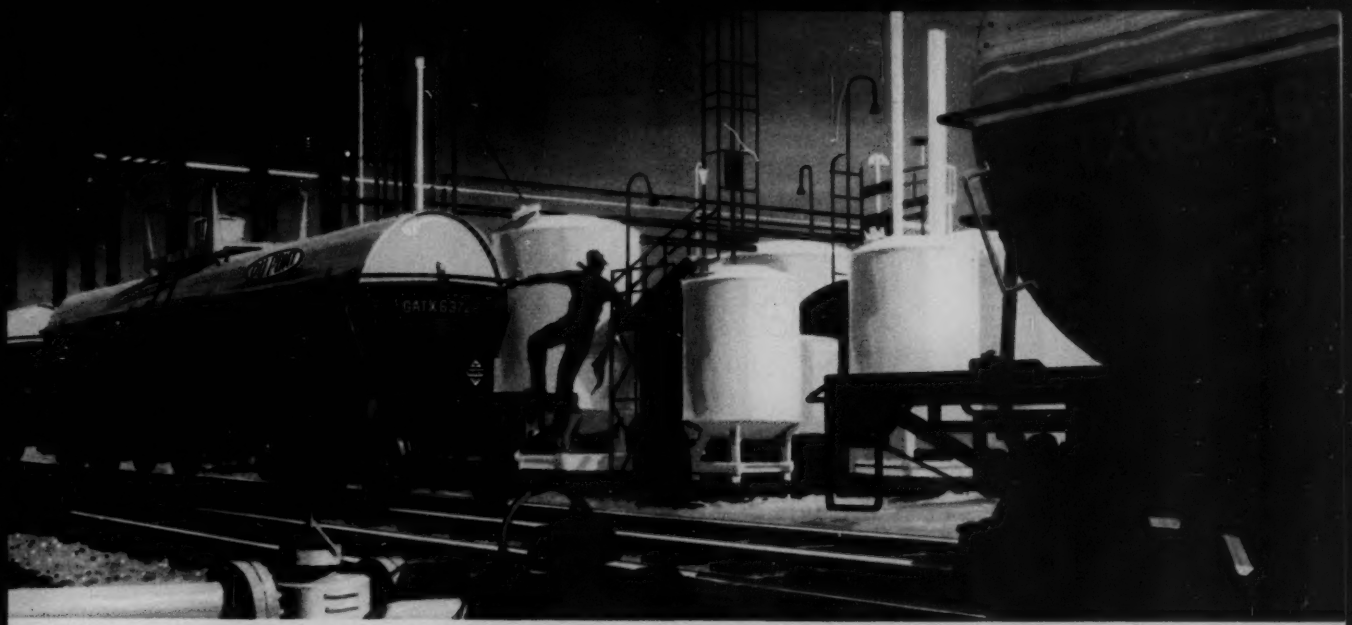


In Texas, these unique supply facilities

for Du Pont tetraethyl lead customers

Refiners in the Gulf Coast and Mid-Continent areas are assured an ample supply and prompt delivery of TEL.

The Du Pont terminal at Beaumont, Texas, (top picture) contains complete modern equipment for TEL storage and handling. It also includes a rail siding for TEL tank cars, which are preloaded and ready for rapid dispatch on a twenty-four-hour basis.

A unique feature of the Beaumont terminal is that it is supplied by sea, with a specially-built TEL tank ship, the MV PETROCHEM, whose home port is Du Pont's largest TEL manufacturing plant, at Deepwater, N. J.

This unusual distribution facility is integrated with other Du Pont Petroleum Chemicals Division operations in Texas . . . such as additives warehouses and the regional sales and technical service offices and laboratories in Houston and Tulsa . . . to provide your refineries in the Gulf Coast and Mid-Continent areas with every possible service that may be required.

E. I. du Pont de Nemours & Co. (Inc.), Petroleum Chemicals Division, Wilmington 98, Delaware.

DU PONT

Better Things for Better Living
. . . *through Chemistry*

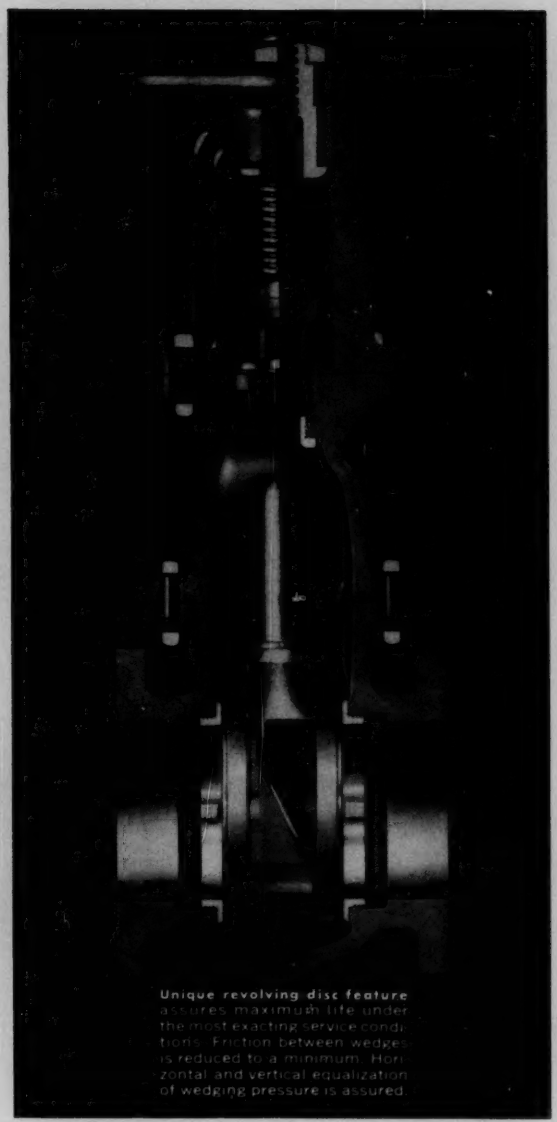
Tetraethyl Lead
and other
Petroleum Additives

FOR SEVERE CORROSIVE CONDITIONS

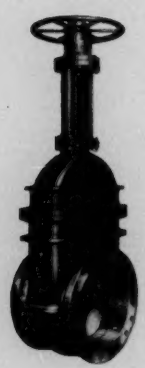
Specify

ALUMINUM GATE VALVES

by Darling



Unique revolving disc feature assures maximum life under the most exacting service conditions. Friction between wedges is reduced to a minimum. Horizontal and vertical equalization of wedging pressure is assured.



Handling corrosive chemicals such as hydrogen peroxide, ammonium nitrate, acetic acid, concentrated nitric acid? Darling Aluminum Gate Valves give you longer life, cut maintenance costs, under these and other severe service conditions. Here's why:

Darling metallurgical engineers have thoroughly tested and standardized on the most highly corrosion-resistant aluminum alloys in use today.

Accurate casting control and precision assembly reduces friction and wear, provides maximum ease of operation.

Darling Double Disc Parallel Seat principle assures freedom from leakage, trouble and downtime.

Darling aluminum alloy valves are available in sizes from ½" through 24". Write us about your requirements and service conditions.

DARLING VALVE & MANUFACTURING CO.

Williamsport 31, Pa.

Manufactured in Canada by Sandilands Valve Manufacturing Co., Ltd., Galt 19, Ont.

DARLING VALVES

Books . . .

labor rate for the craft or crafts involved in the various operations.

Included are sections on conduit, boxes and fittings; service and feeder wiring; branch circuit items; lighting fixtures; panel boards and cabinets; safety switches; hangers and fasteners; underfloor and buss ducts; starters and motors; mounting transformers; outside construction; underground duct and cable; communications and signal systems; demolition, excavation and concrete, and technical information.

(Page, J. S. and Nation, J. G., *Estimator's Electrical Manhour Manual,* Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas, 242 pages, $10.)

Test Yourself on Labor Relations

(Answers)

CASE 1

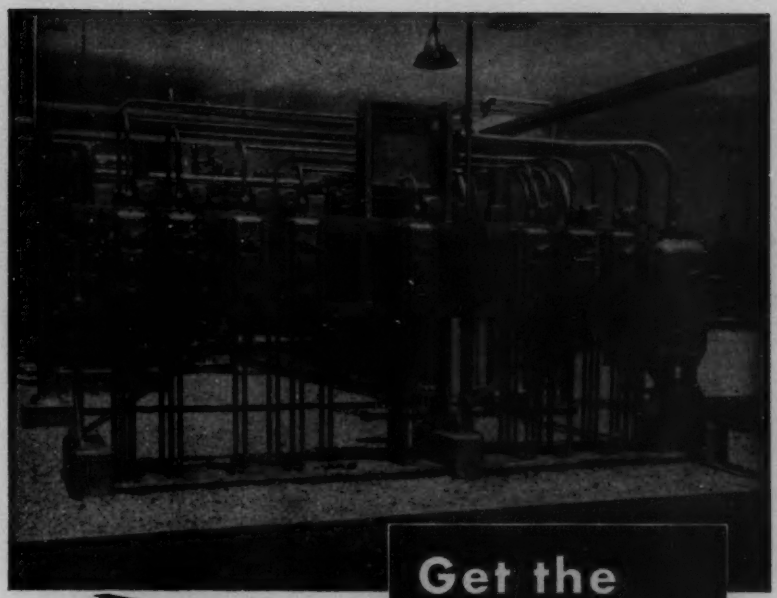
Arbitrator David H. Stowe ruled: "A lawsuit directly against the employer concerning matters arising out of the employment relation is not generally regarded as improper, as evidenced by the fact that legislation has been enacted in which provision is expressly made for the employes to bring suit without fear of employer retaliation—as for example the Fair Labor Standards Act. There is no reason to regard a lawsuit against an employer's customer in any different light. The grievance is sustained and the men should be reinstated to their jobs without loss of pay or seniority."

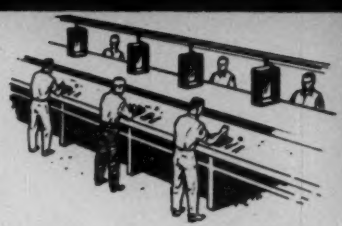
CASE 2

Arbitrator Russell A. Smith ruled: "Reporting pay applies, obviously, to routine scheduling practices when the plant is operating normally, when an employe who has been working appears on his regular schedule without having received prior notice not to report—or when an employe is ordered to report outside of his regular schedule and does report. It cannot be reasonably applied to the situation obtaining upon the termination of an extended strike. Grievance denied."

CASE 3

Arbitrator Ralph T. Seward ruled: "Employes who are sent to jail present a problem. They have not turned their back on their obligations as employes. Their absence is not the result of a decision not to come to work. Typically, it is the result of some action on their part—unrelated to their obligations as employes—which has led society to step in and, by placing them in jail, *prevent* them from coming to work. However, this does not mean that they should not be considered responsible for their presence in jail. John X did not have reasonable cause for absence. The company has the right to discharge him."





Get the economies of factory assembly

. . . plus satisfaction of field personnel by using Nelson Switchracks

Centralized motor control is the modern trend. In the above photo you see a Nelson switchrack with various components including control switches to motors driving the processing pumps in a fractionating plant of Warren Petroleum Corporation.

For outdoor installations Nelson switchracks provide ease of installation and all the advantages of factory assembly and wiring. One purchase order, one receiving report, yet you receive a complete unit. At Nelson each switchrack is specially designed to give the customer the ultimate in performance.

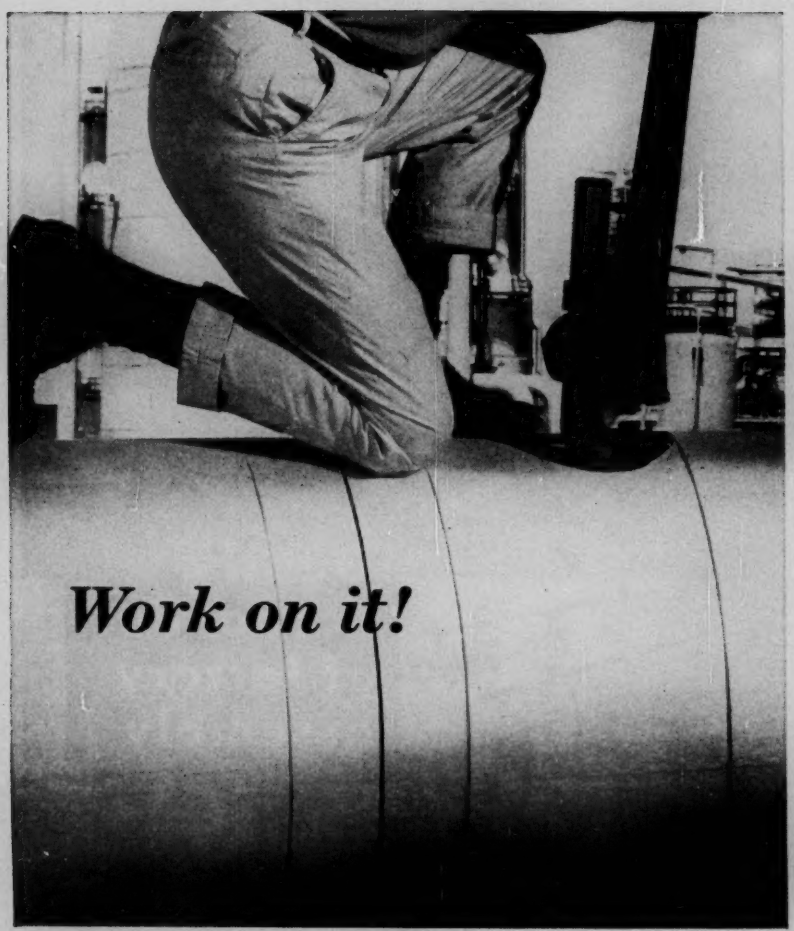
Nelson switchracks are available in either single front or double front, and with or without canopies for weather protection. Components can either be explosion-proof (NEMA 7), watertight and dust-tight (NEMA 4 & 5) or oil immersed (NEMA 8). If you have no preference for arrangement Nelson engineers will design to give you maximum utility in minimum space.

For more complete information write for Bulletin 497

At Nelson . . . *quality* comes first!

NELSON *Electric* MANUFACTURING CO.
TULSA, OKLAHOMA

For more data on advertised products, use Readers' Service Cards, last page.



J-M's new Metal-On® insulation is Thermobestos prejacketed in aluminum. Snaps on pipe quickly . . . surely. Saves the time and cost of separate on-the-job metal application.

Seminars on best installation practices. For plant foremen who wish to keep up to date on new insulation methods and installation practices, J-M regional sales offices will gladly conduct insulation seminars. Contact nearest J-M office.

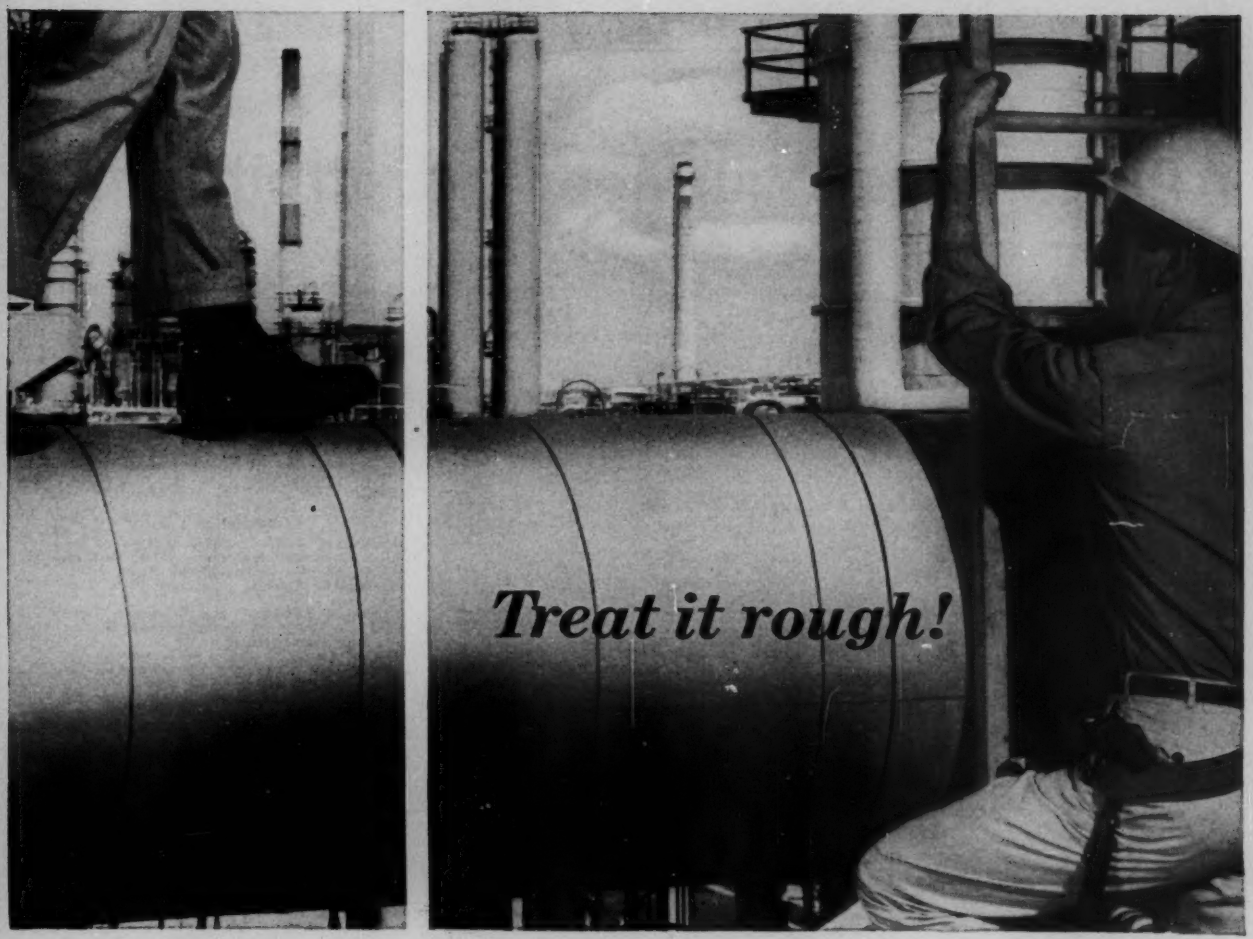
It's tough, durable Johns-Manville

Here's why Thermobestos is the preferred high-temperature calcium-silicate insulation . . . to 1200 F

You know the kind of treatment pipe insulation must take . . . day after day, year after year!

There's no better reason than this for the spiraling growth in Thermobestos® applications throughout the process and power generation industries —an insulation so strong and rigid, so resistant to crushing and compression it is almost structural.

For more data on advertised products, use Readers' Service Cards, last page.

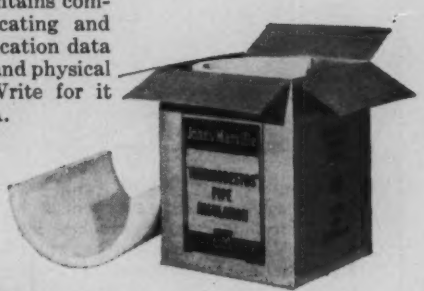


THERMOBESTOS insulation!

Equally important is the ability of Thermobestos to keep fuel costs low. Its *k* factor is the lowest of all insulations generally accepted for process applications. Its moisture resistance, unsurpassed.

Furnished in large, lightweight sections—precision-molded to unusually close tolerances—Thermobestos is easy to handle and install . . . readily adaptable to shop fabrication of fittings and bonds. Large selection of sizes, thicknesses (and quads up to 33" pipe size) permit calcium-silicate installations that are entirely Thermobestos insulation.

You'll want the new Thermobestos booklet for your technical file. It contains complete information on prefabricating and installation practices . . . specification data . . . heat transmission tables . . . and physical and thermal characteristics. Write for it today. Ask for booklet IN-169A. Address Johns-Manville, Box 14, New York 16, N.Y. In Canada, 565 Lakeshore Rd. East, Port Credit, Ontario.



JOHNS-MANVILLE PRODUCTS

JOHNS-MANVILLE

API Refiners Will Meet in Detroit

Featured will be new sessions on tubing inspection and maintenance, and operating practices

The 24th midyear meeting of the API has been mapped out, and refiners attending can look for diversified and well presented material. Two new sessions are scheduled for the program, to be held in Detroit May 9-12. These will cover tubing inspection and maintenance, and operating practices. Also on the 1960 program are group sessions on corrosion, motor gasoline, power fuels, piping, waste disposal, processes, training, analytical research, and automobiles, hydrocarbons and clean air.

There will be two headquarter hotels this year—The Sheraton-Cadillac and Statler Hilton. Sessions will be held four days, Monday through Thursday, rather than three as in 1959. A list of Sessions and topics follows.

CORROSION

1. Mechanism of the Iron-Hydrogen-Sulfide Reaction at Elevated Temperatures (Paul Delahay, Hans Arm, Charles Hudgins, Fritz Hugli, Lester Hulett, Moshin Qureshi, Louisiana State University).
2. Aluminum Exchanger and Condenser Tubes in Petroleum Service (R. L. Hildebrand, Sinclair Refining Co., Harvey, Ill.).
3. Use of Corrosion Probes in Petroleum Refineries (Andrew Dravnieks, Standard Oil Co. (Indiana), Whiting, Ind.).
4. Stainless Steel in Petroleum Refining and Petrochemical Processes (Norton Jaggard and A. V. Alessandria, Arabian American Oil Co., New York).
5. Corrosion Inhibitors in Refinery Process Streams (D. L. Burns, Gulf Oil Corp., Port Arthur, Texas; R. L. Hildebrand, Sinclair Refining Co., Harvey, Ill.; P. D. Thomas, Asiatic Petroleum Co., New York).

MOTOR GASOLINE

1. Piston Engines in the Space Age? (Craig Marks and Darl F. Caris, General Motors Corp., Detroit).
2. Some Sources of Error in Laboratory Knock Ratings (W. E. Adams and J. D. McCullough, Ethyl Corp., Detroit).
3. Combustion Qualities of Future Gasolines (W. E. Morris and K. Hyatt, E. I. du Pont de Nemours and Co., Inc., Wilmington, Del.).

POWER FUELS

1. The Outlook for the Automotive Gas Turbine (G. J. Huebner, Chrysler Corp., Detroit).
2. The Military Mission of the Multifuel Compression Ignition Engine and Its Fuel Requirements (Errol J. Gay, Consultant, Detroit).
3. Premium Quality Fuels for Aircraft Turbine Engines (N. T. Randall, R. J. Pecora, R. Y. Heisler, and S. Hopkins, Texaco, Inc., Beacon, N. Y.).

TUBING INSPECTION AND MAINTENANCE

1. The Significance of Tube Standardization from the Designer's Point of View (J. G. Wilson, Shell Oil Co., New York; Paul Swanson, The M. W. Kellogg Co., Jersey City, N. J.; Otto Schauble, The Lummus Co., New York).
2. The Technique and Significance of Measuring Tube Wall Temperatures in Heaters in Service (F. S. Becker, Sun Oil Co., Newtown Square, Pa.; F. M. Kepler, Sun Oil Co., Marcus Hook, Pa.).
3. Sohio Inspectors Apply Statistical Methods (W. W. McDaniel and R. R. Becker, The Standard Oil Co. (Ohio), Lima, Ohio; W. P. Shontz, The Standard Oil Co. (Ohio), Cleveland).
4. Radiographic Techniques as Applied to On-Stream Inspection Methods (L. A. White, Standard Oil Co. (Indiana), Whiting, Ind.; Thomas Arnesen, Sarnia Inspection Co., Toronto, Ont.).

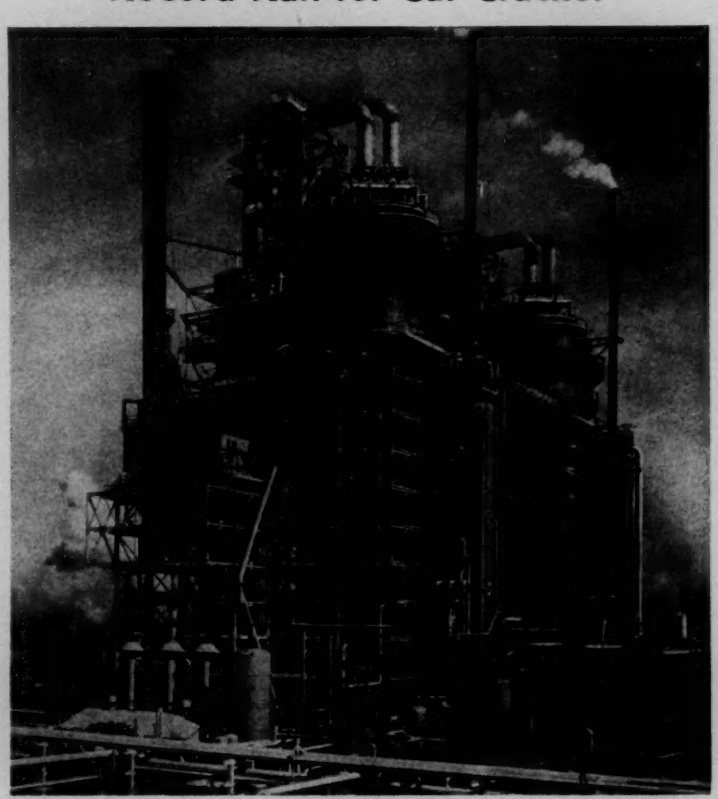
PIPING

1. Basis for and Experience with ASA B31.3-1959, Petroleum Refinery Piping Code (J. P. Mooney, Humble Oil and Refining Co., Baytown, Texas).
2. Economics in Design of Refinery Piping (D. Roger Loper, Standard Oil Co. of Calif., San Francisco, Calif.).
3. Low Temperature Piping Materials (H. M. Howarth, Standard Oil Co. (Indiana), Whiting, Ind.).

LUBRICANTS

1. Background and Status of Current GL-4 Designation for Gear Lubricants (C. R. Noll, Gulf Oil Corp., Pittsburgh).
2. GL-4 Type Gear Lubricants and Their Serv-

Record Run for Cat Cracker



This processing unit at Esso Standard's refinery in Baton Rouge, La., recently ended a continuous run of 1,399 days, surpassing the former world record for fluid catalytic crackers by almost a full year. The former record of 1,065 days was set about two years ago by a catalytic cracking unit at the Lake Charles, La., refinery of Cities Service Oil Co. For the next several weeks, the unit will be off stream for general inspection, repairs and technical improvements. Another of the Baton Rouge refinery's three catalytic plants is only a month away from the old world record of 1,065 days.

M·A·N

The following are some of the products we design and manufacture:

STEAM BOILERS

STEAM POWER STATIONS

TURBINES

DIESEL ENGINES

GAS ENGINES

We recently supplied and installed all apparatuses and structural steelwork required for the

CAT CRACKER AND GAS RECOVERY PLANT
DEUTSCHE SHELL AG
HOHE SCHAAR REFINERY, HAMBURG

MASCHINENFABRIK AUGSBURG-NÜRNBERG AG · GUSTAVSBURG WORKS
GUSTAVSBURG/HESSEN (GERMANY) · REPRESENTATIVES IN ALL COUNTRIES

For more data on advertised products, use Readers' Service Cards, last page.

ENGINEERED PRODUCTS

for Petroleum Refining

COMBAT CORROSION PROBLEMS

Garlock LATTICE-BRAID† Teflon Packings are perfect on pumps and engines in petrochemical, oil and gas service. They are strong, long-lasting, chemically inert. Withstand temperatures ranging from −120°F to +500°F. Less gland pressure is required to effect an adequate seal, resulting in longer sleeve and packing life, less downtime. Catalog AD-131.

Garlock CHEMISEAL† Mechanical Seals with Teflon* bellows possess greater immunity to corrosion than other designs. Easy to handle and install, do not score shafts, engineered to give a life expectancy many times that of other seals. Available in standard sizes to fit all pump shafts ⅞" to 2⅛" shaft. Seals against all media in pressures to 100 psi at 75°C or 75 psi at 100°C. Catalog AD-164.

Garlock Teflon-jacketed Gaskets give you the advantage of using Teflon without sacrificing resiliency and deformability . . . particularly important on your glass-lined process equipment, standard metal flanges, and glass pipe flanges and fittings. Garlock offers four basic designs—slit envelope, milled envelope, formed shield, double jacket —and a wide selection of filler materials and thicknesses. Catalog AD-154.

Garlock GUARDIAN† Gaskets provide a safe, positive seal against high temperatures and pressures of steam, oils, gases, liquids. Gasket density, introduced during manufacture, assures dependable sealing under varying service conditions. Used at temperatures to 1050°F, pressures to 2500 psi . . . available in round, oval, square, flat side, diamond, pear and other shapes in practically any size. Large regional warehouse stocks are maintained at Camden, Cleveland, Houston and San Francisco. Catalog AD-104.

GARLOCK

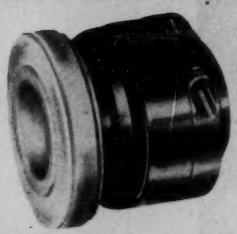
For more complete information, call your Garlock representative at one of Garlock's 26 sales offices and warehouses throughout the U.S. and Canada. Or, write The Garlock Packing Company, Palmyra, New York.

Canadian Div.: The Garlock Packing Company of Canada Ltd.

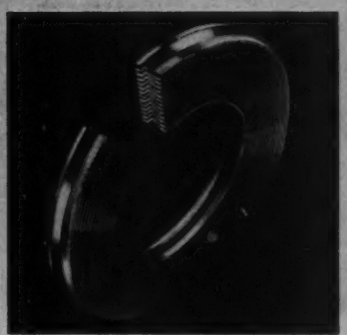
Plastics Div.: United States Gasket Company

Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded & Extruded Rubber, Plastic Products

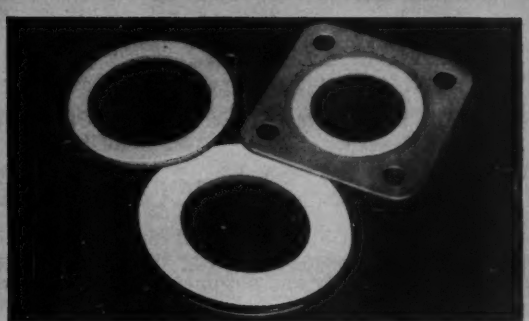
†Registered Trademark
*DuPont Trademark for TFE Fluorocarbon Resin



CHEMISEAL Mechanical Seals can be installed quickly and simply, offer leak-proof sealing without shaft wear . . . resist most reactive chemicals.



GUARDIAN Gasket V-shaped metal plies have an automatic spring action that reacts to variations in compression, internal pressures, and temperature changes. Assure leak-proof seal under most severe conditions.



Teflon-jacketed Gaskets offer the advantage of applying Teflon without the loss of resiliency . . . ideally suited to pipes, flanges in processing.

LATTICE-BRAID Teflon Packing lasts far beyond the limits of other packings . . . gives maximum service over wide range of temperatures, pressures. Only Garlock can give you Lattice-Braid.

ENGINEERED PRODUCTS

for Petroleum Refining

COMBAT CORROSION PROBLEMS

Garlock LATTICE-BRAID† Teflon Packings are perfect on pumps and engines in petrochemical, oil and gas service. They are strong, long-lasting, chemically inert. Withstand temperatures ranging from −120°F to +500°F. Less gland pressure is required to effect an adequate seal, resulting in longer sleeve and packing life, less downtime. Catalog AD-131.

Garlock CHEMISEAL† Mechanical Seals with Teflon* bellows possess greater immunity to corrosion than other designs. Easy to handle and install, do not score shafts, engineered to give a life expectancy many times that of other seals. Available in standard sizes to fit all pump shafts $\frac{7}{8}$" to $2\frac{1}{8}$" shaft. Seals against all media in pressures to 100 psi at 75°C or 75 psi at 100°C. Catalog AD-164.

Garlock Teflon-jacketed Gaskets give you the advantage of using Teflon without sacrificing resiliency and deformability . . . particularly important on your glass-lined process equipment, standard metal flanges, and glass pipe flanges and fittings. Garlock offers four basic designs—slit envelope, milled envelope, formed shield, double jacket—and a wide selection of filler materials and thicknesses. Catalog AD-154.

Garlock GUARDIAN† Gaskets provide a safe, positive seal against high temperatures and pressures of steam, oils, gases, liquids. Gasket density, introduced during manufacture, assures dependable sealing under varying service conditions. Used at temperatures to 1050°F, pressures to 2500 psi . . . available in round, oval, square, flat side, diamond, pear and other shapes in practically any size. Large regional warehouse stocks are maintained at Camden, Cleveland, Houston and San Francisco. Catalog AD-104.

GARLOCK

For more complete information, call your Garlock representative at one of Garlock's 26 sales offices and warehouses throughout the U.S. and Canada. Or, write The Garlock Packing Company, Palmyra, New York.

Canadian Div.: The Garlock Packing Company of Canada Ltd.

Plastics Div.: United States Gasket Company

Order from the Garlock 2,000 . . . two thousand different styles of Packings, Gaskets, Seals, Molded & Extruded Rubber, Plastic Products

†Registered Trademark
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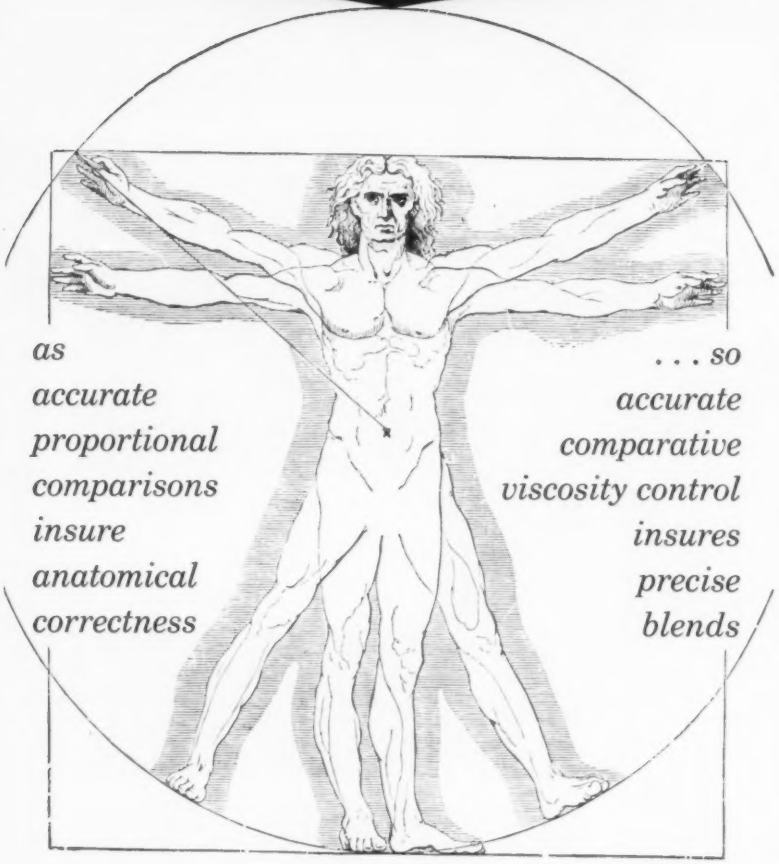
CHEMISEAL Mechanical Seals can be installed quickly and simply, offer leak-proof sealing without shaft wear . . . resist most reactive chemicals.

GUARDIAN Gasket V-shaped metal plies have an automatic spring action that reacts to variations in compression, internal pressures, and temperature changes. Assure leak-proof seal under most severe conditions.

LATTICE-BRAID Teflon Packing lasts far beyond the limits of other packings . . . gives maximum service over wide range of temperatures, pressures. Only Garlock can give you Lattice-Braid.

Teflon-jacketed Gaskets offer the advantage of applying Teflon without the loss of resiliency . . . ideally suited to pipes, flanges in processing.

WHAT HAS THIS TO DO WITH VISCOSITY?



as accurate proportional comparisons insure anatomical correctness

. . . so accurate comparative viscosity control insures precise blends

and you can make them better with a

Bendix* Viscomparator

Accurate blending of petroleum products to a specification viscosity can be controlled continuously and automatically. The viscosity of the process fluid is compared with that of a reference sample at operating temperatures. Wide-range temperature compensation is inherent in the Bendix Viscomparator's design. Its sensing element withstands up to 650° F. (343° C.) and 1,000 psi.

For complete information about this surest, most modern method of controlling viscosity, write Dept. W2.

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Happenings . . .

ice Performance (Dr. O. C. Bridgeman, Phillips Petroleum Company, Bartlesville, Okla.).
3. A third paper will also be given.

OPERATING PRACTICES

1. Safe "Ups and Downs" for Refining Units (A. H. Hayes, Standard Oil Co. (Indiana), Whiting, Ind.).
2. Towers are Touchy (R. W. Ballmar, The Standard Oil Co. (Ohio), Cleveland).
3. Procedures: Starting Up and Shutting Down Atmospheric and Vacuum Crude Distillation Units at the Gulf Port Arthur Refinery (J. A. Burns and W. S. Bonnell, Gulf Oil Corp., Port Arthur, Texas).

PROCESSES

1. Lowered Investments Improve Economics of Fluid Coking (R. O. Wright, A. L. Saxton, and H. N. Weinberg, Esso Research and Engineering Co., Madison, N. J.).
2. Isocracking: A Versatile New Refining Tool (J. W. Scott, J. A. Robbers, N. J. Patterson, and H. M. Lavender, California Research Corp., Richmond, Calif.).
3. Impact of Recently Developed Processes on Refining Technology (R. C. Kersten and G. F. Asselin, Universal Oil Products Co., Des Plaines, Ill.).

WASTE DISPOSAL

1. Can Refinery Pollution Control Have a Payout? (J. D. Frame, Cities Service Research and Development Co., New York).
2. Waste Disposal at Texaco's Puget Sound Refinery (J. J. Samsel, Texaco, Inc., New York).
3. Design Aspects of Air-Flotation Treatment of Combined Refinery Waste Waters (E. R. Roth, J. D. Helwig, and W. A. Hall, The Atlantic Refining Co., Philadelphia).
4. The API Manual on Disposal of Refinery Wastes—What It Is and What It Can Do For You (S. O. Brady, Humble Oil and Refining Co., Baytown, Texas).

AUTOMOBILES, HYDROCARBONS AND CLEAN AIR

1. Petrochemical Reaction Products in Air Pollution (E. R. Stephens, E. F. Darley and O. C. Taylor, University of California; W. E. Scott, W. E. Scott and Associates, Perkasie, Pa.).
2. Factors Affecting Carburetor Vapor Losses (W. F. Deeter and R. G. Jewell, Richfield Oil Corp., Anaheim, Calif.).
3. Relation of Fuel Components to Hydrocarbons Emitted in Automotive Engine Exhaust (R. W. Hurn and Staff, U. S. Bureau of Mines, Bartlesville, Okla.).
4. Status of Motor Vehicle Exhaust Afterburners (W. L. Faith, Air Pollution Foundation, San Mareno, Calif.).

ANALYTICAL RESEARCH

1. Use of Light Scattering, Electron Microscopy, and Polarography in Oil Stability Studies (J. W. Loveland, G. R. Dimeler, and L. G. Bostwick, Sun Oil Co., Marcus Hook, Pa.; and L. J. Cali, Callery Chemical Co., Callery, Pa.).
2. Simultaneous Measurement of Water and Fuel Contamination in Crankcase Oils by Automatic Vacuum Distillation (R. K. Siegfriedt and D. A. DeWoody, Socony Mobil Oil Co., Inc., Brooklyn).
3. New Metallo-organic Analytical Standards Lead to Savings
4. A Study of an Intrinsic Contaminant in Petroleum—The Nature of Vanadium in Asphaltenes (A. A. Wolsky and F. W. Chapman, Jr., The Atlantic Refining Co., Philadelphia).
5. The Determination of Nitrogen and Oxygen in Organic Materials Utilizing Gas Chromatography (R. L. Scott, D. E. Smith, J. E. Puckett, and B. J. Heinrich, Phillips Petroleum Co., Bartlesville, Okla.).
6. Polarographic Method for Parts Per Billion of Copper and Lead in Catalytic Reformer Feedstocks (B. W. Samuel and J. V. Brunnock, BP

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65,000 GALLON PER MINUTE HUDSON COOLING TOWER SUPPLIED IN EMERGENCY

Faced with shutdown of process units because of a damaged, partially inoperative cooling tower, a large Gulf Coast oil refiner called upon HUDSON for emergency supply of new cooling capacity. Despite necessity for modification of HUDSON standard design to conform to existing foundation, and though working under adverse condition of stepwise removal and replacement of partially operating old tower, more than 30 percent of the new HUDSON tower was operating in less than five weeks. The promised time schedule was met, the crisis averted, and guaranteed cooling performance exceeded.

Performance of such special services with speed, ability and integrity is a measure of the quality of HUDSON service — whether in repairing or replacing an operating cooling tower, or in designing and supplying a complete integrated system with balanced use of water and direct air for cooling all process streams.

In addition to water cooling towers, HUDSON designs and manufactures SOLO-AIRE units (for cooling solely with air), and COMBIN-AIRE units (for cooling with combination of maximum air and minimum water). Avail yourself of HUDSON's years of experience in integration of these all-encompassing categories of equipment into cooling systems utilizing optimum ratio of air and water balanced to best meet specific conditions of climate, process, and water availability and quality.

ONLY HUDSON OFFERS — — — —
process stream cooling systems integrating cooling towers, Solo-aires and Combin-aires for optimum balance of air and water cooling.

It will pay to consult Hudson during processing design stage of new projects.

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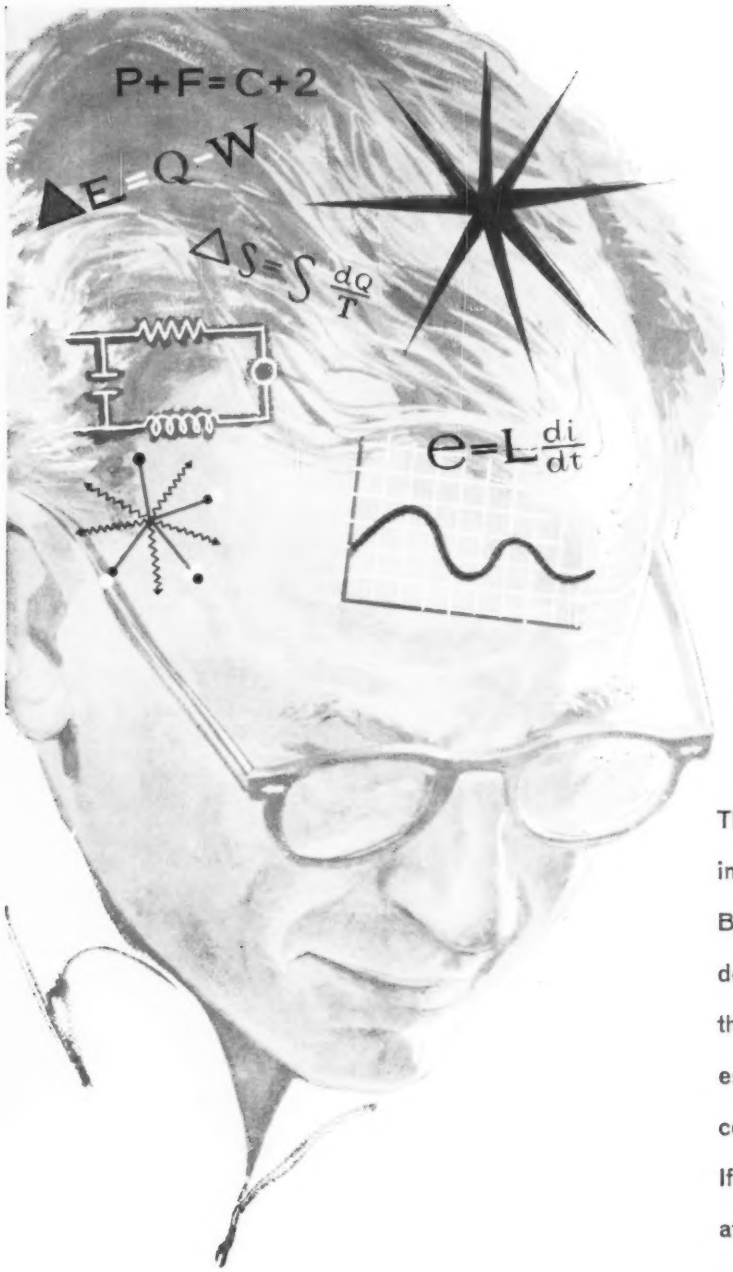

Instruments of the Mind

The engineer has his specialized instruments, as does the surgeon. But the work these instruments perform depends upon the thought that guides them. Knowledge and judgment are essential to any project, but superiority comes only from originality... ideas. If there is a new and better way, engineers at Brown & Root will find it. Practical results in greater efficiency at lower costs have built a world-wide reputation for engineering by Brown & Root.

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For more data on advertised products, use Readers' Service Cards, last page.

Research Centre, Sunbury-on-Thames, England). 7. Analytical Distillation by Gas Chromatography—Programmed Temperature Operation. (F. T. Eggertsen, S. Groennings, and J. J. Holst, Shell Development Co., Emeryville, Calif.).

TRAINING

No details currently available.

Oil Sands Project Involves Comprehensive Research

The most comprehensive research project ever undertaken to release liquid hydrocarbons from the Athabasca oil sands of Northern Alberta was announced recently coincident with the formation of a four-company partnership to carry forward the enterprise. The four companies are Imperial Oil, Ltd., Cities Service Athabasca, Inc., a subsidiary of Cities Service Oil Co., which will operate the project, Richfield Oil Corp., and Royalite Oil Co., Ltd. Imperial, Cities service and Richfield will each hold a 30 percent interest, while Royalite's will be ten percent.

Existence of tremendous hydrocarbon deposits along the Athabasca River has been known to petroleum scientists for many decades. Many unsuccessful efforts have been made to separate oil from the sands on a basis which would be commercially competitive with other means of producing oil. The new partnership believes the problems can be solved by new techniques.

Research activities have been carried on individually by the partners for several years, searching for a method of extraction of oil from the Athabasca sands on a commercially feasible basis. The present research program was begun two years ago by Cities Service. Subsequently, a $3.5-million pilot plant was built at Mildred Lake, roughly 30 miles north of McMurray.

The plant includes a 3000-bpd distillation unit, extensive separation equipment and numerous collateral facilities. A unique mining "wheel," which has proved highly successful in the surface mining of coal in Europe, strips the sand from the surface. In the Athabasca project, the sands are put through a series of processes which remove the oil and return clean white sand to the mined areas.

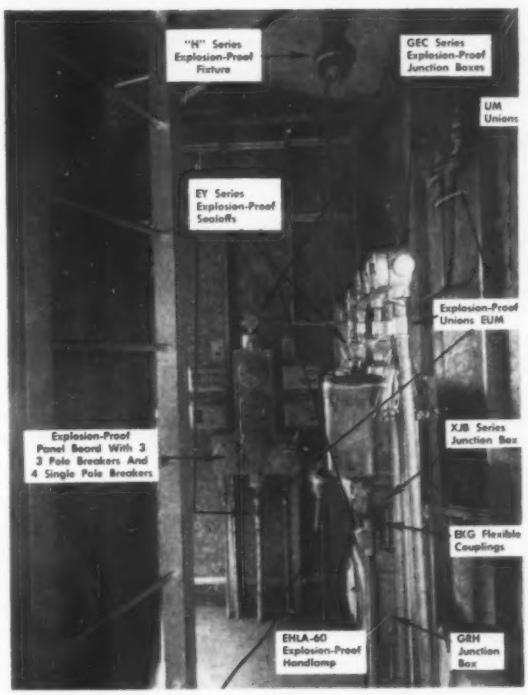
Bureau of Mines Reports On 1959 Achievements

Bureau of Mines achievements in coal, petroleum, and other minerals research, helium production, and health and safety have been cited by Secretary of the Interior Fred A. Seaton in a report to President Eisenhower for the 1959 fiscal year. In petroleum and natural gas projects, the Bureau participated in long-range cooperative studies to estimate future requirements of petroleum and natural-gas fuels, and outline ways of assuring supplies. Oil and gas technology moved ahead with Bureau development of new production methods, improved instrumentation, and more accurate

More and more refineries are turning to

KILLARK ELECTRICAL FITTINGS & FIXTURES

for GREATER SAFETY MAXIMUM DURABILITY


"H" Series Explosion-Proof Fixture
GEC Series Explosion-Proof Junction Boxes
UM Unions
EY Series Explosion-Proof Sealoffs
Explosion-Proof Unions EUM
Explosion-Proof Panel Board With 3 3 Pole Breakers And 4 Single Pole Breakers
XJB Series Junction Box
EKG Flexible Couplings
EHLA-60 Explosion-Proof Handlamp
GRH Junction Box

This Killark installation at a midwest refinery is typical of the growing recognition of Killark design and quality where absolute safety and permanence of installation are such important considerations. Here are a few good reasons:

- *Non-Sparking Aluminum*
- *Complete Freedom from Rust and Corrosion*
- *Lightweight for Faster, Easier Installations*
- *High-Strength Alumalloy Construction*
- *U. L. Approved for Hazardous Locations*

FREE CONDENSED CATALOG
Fully illustrated with dimensions and specs. Ask for Catalog No. 59.

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ELECTRIC MANUFACTURING CO.
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Sold Through Leading Distributors:
WAREHOUSE STOCKS in NINETEEN CITIES in U. S. and CANADA!

For more data on advertised products, use Readers' Service Cards, last page.

POWELL LUBRICATED PLUG VALVES

performance that makes a world of difference

For over a century, Powell has supplied vital valves to the all-important oil industry. Today, the complete line includes valves of all types. Powell has the greatest variety of sizes, designs, pressures and metals. There is one to cover every valve need in oil refineries, petrochemical installations, and storage facilities everywhere.

Powell engineers and metallurgists will gladly make a special analysis of your requirements and submit recommendations to fill all your valve needs. Write directly to us . . . or consult your local Powell distributor.

Powell . . . world's largest family of valves

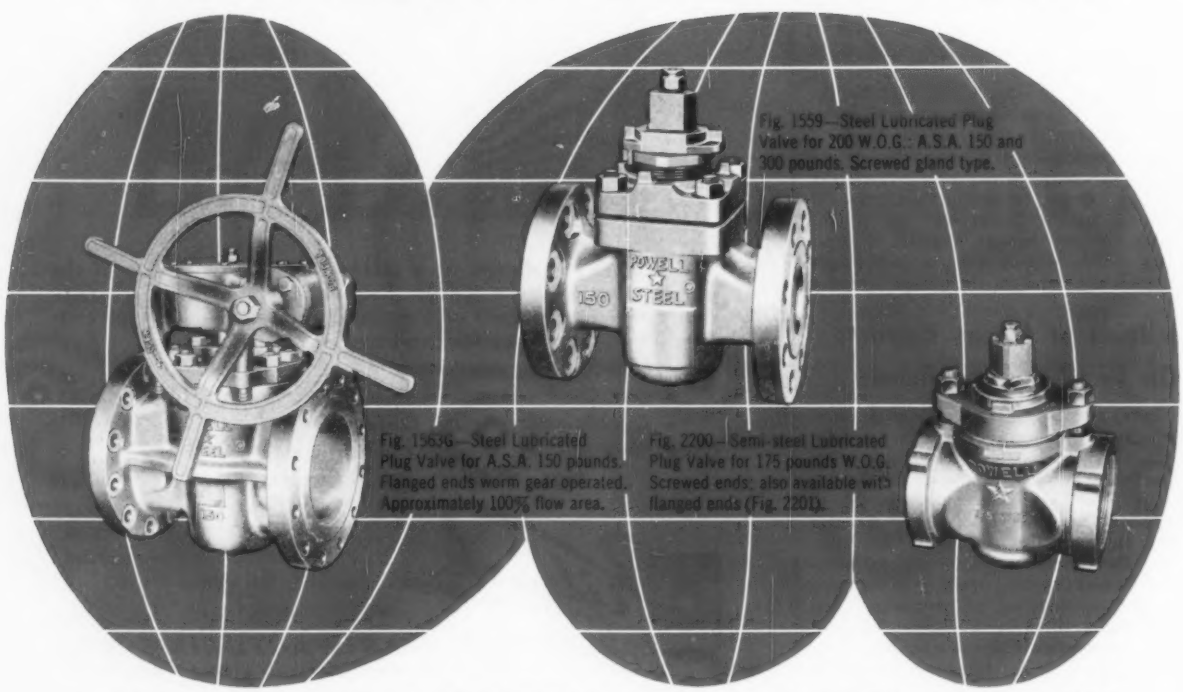

Fig. 1559—Steel Lubricated Plug Valve for 200 W.O.G.; A.S.A. 150 and 300 pounds. Screwed gland type.

Fig. 1563G—Steel Lubricated Plug Valve for A.S.A. 150 pounds. Flanged ends worm gear operated. Approximately 100% flow area.

Fig. 2200—Semi-steel Lubricated Plug Valve for 175 pounds W.O.G. Screwed ends; also available with flanged ends (Fig. 2201).

THE WM. POWELL COMPANY • DEPENDABLE VALVES SINCE 1846 • CINCINNATI 22, OHIO

For more data on advertised products, use Readers' Service Cards. last page.

Happenings . . .

techniques for determining basic characteristics of hydrocarbons. In the helium field, the Department of the Interior renewed its request for legislation that would encourage private industry to build and maintain up to 12 new plants to recover huge quantities of helium now lost when it goes to fuel markets as a constituent of natural gas.

At Laramie, Wyo., depleted uranium in the form of uranium oxide is being tested as a catalyst in laboratory-scale refining of shale oil. Such experiments already indicate definite promise for depleted uranium in this application. However, further studies are necessary before the performance of this material as an industrial catalyst can be thoroughly evaluated. Large quantities of depleted uranium are available for non-nuclear uses.

Ike's Gas Tax Increase Assailed by API Prexy

President Eisenhower's proposal for raising the federal gasoline tax another half-cent is "a heavy blow to American motorists still reeling from a $500 million annual boost imposed less than four months ago," says the president of API. Frank M. Porter called on Congress to reject the proposed increase, made in the national-budget message January 18, and to honor its pledge to let last fall's temporary hike of one cent expire on schedule next year. The President recommended that both last fall's one-cent increase and the proposed additional half-cent boost be continued until June 30, 1964.

Big Carbon Companies Trade on Investments

Continental Carbon Co. and Columbian Carbon Co. will coordinate manufacturing facilities of their two major plants in the European area. Columbian Carbon has purchased an interest in Continental Carbon's new 25-million-pound carbon black plant in Rotterdam, Holland. This plant will be operated as Continental-Columbian Carbon (Nederland) N.V. and will be in production in mid-spring, 1960. Continental Carbon Co. has purchased an interest in the new 60-million-pound carbon black plant being built by Columbian Carbon at Trecate, near Milan, Italy. This plant will be completed in the fall and will be operated as Columbian Continental Europa S.p.A.

Socony Mobil Repeats Denial of 'Price Fixing'

Denials that his company engaged in a price conspiracy as alleged in a 1958 government lawsuit were repeated recently by Albert L. Nickerson, president of Socony Mobil Oil Co., Inc. In repeating the denial, Nickerson said he

NEW ELLIOTT TUBE EXPANDERS **roll tubes into thick sheets in one pass**

Use of **NEW** continuous-rolling technique here—shows uniform seal, with all Keys preserved, and no signs of shear

OLD step-rolling method results in non-uniform surface . . . distortion of Keys where rolls have overlapped

Better seal...Smoother surface... Much Faster operation

This new concept in tube expanders was developed by Elliott to roll the thickest tube sheets. Using a continuous-rolling method, it eliminates many problems common to step-rolling, may be operated protractively or retractively, saves time, assures uniform, smooth surfaces, avoids annular voids or erratic tube inside diameters, provides better seal.

Accessories

Elliott also makes a complete line of retubing accessories, including both electric and air magnetic Tube Rolling Controls, Tube Gages, Tube Plugs, Tube Cutters, etc.—in addition to a complete line of tube expanders. *Ask for Bulletin Y-52.*

ELLIOTT Company
LAGONDA PLANT, SPRINGFIELD, OHIO
Y9-5

For more data on advertised products, use Readers' Service Cards, last page.

STRONG is the word for Centrifugally Cast Pipe

. . . and the alloying is selected so that you will get high resistance to corrosion or high resistance to extreme heat or high resistance to both, as you require.

Centrifugally Cast Pipe has been a major DURALOY item since 1933 when we pioneered such high alloy castings in this country. Standard pipe production is in the following classification:

Outside Diameter	Minimum Wall	Length
2½" to 3"	1/4"	88" maximum
3" to 6" Inclusive	5/16"	110" maximum
Over 6" to 12" Inclusive	3/8"	168" maximum, 24" minimum
Over 12" to 14" Inclusive	7/16"	168" maximum, 24" minimum
Over 14" to 20" Inclusive	1/2"	180" maximum, 48" minimum
Over 20" to 24" Inclusive	1/2"	88" maximum
Over 24" to 32" Inclusive	5/8"	80" maximum

RESISTANT is the word for Chrome-Nickel Alloying

The strength of Centrifugally Cast Pipe comes largely from the exceptionally uniform dense grain structure.

If you require a gas or liquid pipe line or a process tube requirement calling for high strength plus high resistance to corrosion and/or temperatures in the piping, DURALOY Centrifugally Cast Pipe will meet your specifications with complete satisfaction. This is the record of our castings in industry for many, many years.

The DURALOY Company
OFFICE AND PLANT: Scottdale, Pa.
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ATLANTA OFFICE: 76—4th Street, N.W.
CHICAGO OFFICE: 332 South Michigan Avenue
DETROIT OFFICE: 23906 Woodward Avenue, Pleasant Ridge, Mich.

Happenings . . .

welcomed the early trial, which began February 1. The litigation, which is taking place in Tulsa, involves 29 oil companies.

"We have been at a loss for nearly three years to understand this indictment. This case appears to be one of the most unwarranted anti-trust prosecutions on record," Nickerson said. "The government lawyers have admitted that the alleged 'conspiracy' is 'implied,' and that their evidence is circumstantial," he added. The trial is welcomed by Socony Mobil, according to Nickerson, as a long-sought opportunity to have its innocence determined. Companies involved are charged with unlawful combination and conspiracy to raise, fix and stabilize the prices of crude oil and automotive gasoline. Magnolia, formerly Socony Mobil's southwest affiliate, retains its separate identity as a defendant despite its merger on October 1 into Mobil Oil Co., operating division for Socony Mobil in the United States and Canada. Government lawyers allege that an unlawful combination and conspiracy began some time in 1956 and continued through January, 1957.

Three Key Companies Form New Methane Firm

The interests of Continental Oil Co., the Union Stock Yard and Transit Co. of Chicago and the Royal Dutch Shell Group of companies in the liquefied natural gas field are to be developed through the medium of a jointly owned company to be known as Conch Methane Co., Ltd. Continental Oil and Union Stock Yards, both American companies with head offices in Houston and Chicago, respectively, have been doing research in the liquefied natural gas field through their joint subsidiary, Constock International Methane, Ltd.

In response to inquiries about the purchase by the Royal Dutch Shell Group in Constock, Continental Oil stated that the interest acquired was 40 percent. New shareholders are Continental, 40 percent; Royal Dutch Shell Group, 40 percent, and Union Stock Yard and Transit Co. of Chicago, 20 percent. Constock was formerly owned 50 percent each by Continental and Union Stock Yards.

API-Financed Research May Stop Air Pollution

Highly significant scientific data which may eventually lead to a solution to air pollution have been developed through research financed by the American Petroleum Institute, according to *Oil Facts*. The Institute has invested more than $1.3 million in air pollution studies since 1952. During the same period indivdual oil companies spent an additional $66 million in the development of controls

NOW IS THE TIME TO BUILD YOUR PHENOL PLANT

PROCESS ENGINEERING IS BETTER!

Thinking of producing phenol? Looking for the optimum investment in facilities? Today, with its unequalled engineering-construction background of phenol-from-cumene projects, Kellogg can build a phenol plant at a considerably lower initial investment than five years ago.

INITIAL INVESTMENT IS LOWER!

Operating costs are also lower. As proved recently in the case of one major phenol producer, chemical manufacturers realize the ultimate economies of a Kellogg-built plant when the contract is on a turn-key basis. Kellogg, in this instance, working closely with customer's engineers, was completely responsible for engineering, procurement, construction. The customer, for a lump sum, took over a complete plant—producing phenol and acetone to specs. *within 14 months after the contract was awarded.*

PLANT COMPLETION IS FASTER!

If a phenol plant is in your company's future, investigate *now* the time-and-money-saving advantages of Kellogg's turn-key approach.

OPERATING COSTS ARE LOWER!

THE M. W. KELLOGG COMPANY, 711 THIRD AVENUE, NEW YORK 17

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KELLOGG

Engineered Features of Super-Silvertop Steam Traps Assure Trouble-Free Operation

For trouble-free steam trap operations, with engineered, maintenance reducing features, install Super-Silvertops. First, there are no narrow cored passages to become clogged or to limit the flow. Second, a patented center tube guide arrangement of the bucket assures positive seating—keeps all parts in proper alignment. Third, valves and seats are made of Anderloy, an alloy developed to resist corrosive action. And fourth, reverse flow feature keeps the bucket stationary even under heavy loads, cleans trap of sediment and dirt. Send coupon for Bulletin #26, giving sizing details of these remarkable trouble-free traps.

A TRAP FOR EVERY PURPOSE

THE V. D. ANDERSON COMPANY
division of International Basic Economy Corporation
1953 West 96th Street • Cleveland 2, Ohio

Please send without obligation your Bulletin #26 giving sizing details.

Name_____ Title_____
Company_____
Address_____
City_____ Zone_____ State_____

ANDERSON *SUPER•SILVERTOPS*

Happenings . . .

designed to provide purer air in communities where they operate. The U.S. government also has conducted intensive studies in the field, the new API publication said. API has established 14 projects at such places as the Franklin Institute, the universities of Wisconsin, Illinois and California, Stanford Research Institute, the Industrial Hygiene Foundation and the Armour Research Foundation. Nine projects have been completed. Work on the others is still in progress.

One major result of API-sponsored air chemistry research at the Franklin Institute was the design and construction of a machine unofficially called "Silent Sam, the Smog Detective." The device is a long-range infra-red spectrometer which not only identifies air pollutants in the parts-per-million range, but also brews its own synthetic smog for experimental use.

—Changing Times—

General Petroleum Corp. officially became Mobil Oil Co. on January 1—in line with previously announced integration of Socony Mobil Oil Co. and its subsidiaries.

Monsanto Chemical Co. reports that its **safety record for 1959 was second only to all-time company record year** of 1958.

Shell Companies Foundation will give $1.4 million in 1960 for educational, charitable, religious, and public service organizations. Contribution, one of largest in the Industry—sets new high for foundation.

The highly successful Oil Centennial celebration held at Titusville, Pa., during 1959 **closed out accounts with balance of $25,000.** Money has been donated to Drake Well Memorial Park to improve museum there.

Union Carbide Plastics Co.'s Texas District sales office, previously located at 1511 Bryan St., Dallas, **has been moved to 6300 North Central Expressway, Dallas.**

Dow Chemical Co. plans to market in spring a fluid to replace antifreeze, water and rust inhibitors in automobile cooling systems. Additive would provide what amounts to sealed cooling system for a year.

Mobil International Oil Co. has acquired interest in Barbados Union Oil Co.—independent oil refiner and marketer serving the island of Barbados, West Indies.

For more data on advertised products, use Readers' Service Cards, last page.

THE TWO OUTSTANDING

PLATINUM REFORMING CATALYSTS

ENGELHARD
INDUSTRIES, INC.
CHEMICAL DIVISION
113 ASTOR STREET · NEWARK 2, NEW JERSEY

IMPORTANT NOTICE:

These two well established platinum reforming catalysts having distinctive product distribution patterns are now manufactured by Engelhard and supplied under a single license and catalyst supply contract. This new, singular service advantage allows you to choose the catalyst best suited to particular processing or economic conditions in a given installation. Greater latitude in reforming results thus assures maximum economy in each individual refining operation.

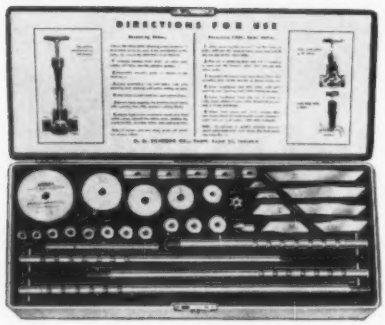
Investigate the unique performance of these outstanding platinum reforming catalysts. They provide longest periods of operation — *regeneration in situ!* They deliver important yield increases at high octane levels — *in existing equipment!* They reduce costs sharply—*to lowest level!*

An Engelhard representative will be glad to give you detailed information upon request. ★ ★ ★

PROMPT PRECIOUS METAL SCRAP RECOVERY SERVICE • ENGELHARD PROCEDURES RECOVER 100% OF ASSAYED PRECIOUS METAL CONTENT • IRVINGTON-BAKER REFINING DIVISION

For more data on advertised products, use Readers' Service Cards, last page.

RESEATS VALVES and BIBBS QUICKLY ECONOMICALLY



Easily pays for itself on the first two jobs!

Reseats flat and tapered-seat globe or angle valves—all bibbs and faucets—in place, quickly and accurately. The saving, over tearing out and renewing leaky valves and fixtures, is tremendous.

Cutters operating under screw feed, leave worn, scored seats glass-smooth, level, absolutely accurate and tight.

A guide pilot centers each cutter; a tapered cone centers each spindle. Perfect alignment is inevitable. Cutters guaranteed. Write for literature!

2" for ¼" to 2" valves and ¼" to ⅜" bibbs
List price $59.85

3" for ¼" to 3" valves and ¼" to ⅜" bibbs
List price $79.50

FREE **catalog showing our pipe repair clamps, saddles, and reseating tools**

M. B. SKINNER CO.
SOUTH BEND 21, INDIANA

Meetings Calendar

Feb.	
21–24	**American Institute of Chemical Engineers,** Meeting. Hotel Biltmore, Atlanta.
23–26	**American Society of Mechanical Engineers,** Symposium on Thermal Properties of Gases, Liquids and Solids, Purdue University.
25	**American Chemical Society,** Petroleum Symposium, Delaware Valley Regional Meeting, Bellevue-Stratford Hotel, Philadelphia.
26	**Natural Gasoline Association of America,** Permian Basin Regional Meeting, Lincoln Hotel, Odessa, Texas.
March	
6– 9	**ASME,** Gas Turbine Conference and Exposition, Rice Hotel, Houston.
11	**ACS-AIChE,** Joint Technical Meeting, Lamar State College of Technology, Beaumont, Texas.
14–18	**NACE,** Annual Meeting, Memorial Auditorium, Dallas.
18	**NGAA,** Oklahoma Regional Meeting, Biltmore Hotel, Oklahoma City.
28–30	**Western Petroleum Refiners Association,** Annual Meeting, Hilton Hotel, San Antonio.
29	**AIChE,** Separation Processes Meeting, Philadelphia-Wilmington Section, University Museum, University of Pennsylvania.
April	
12–13	**Petroleum Industry Electrical Association,** Conference and Exhibition, Municipal Auditorium, Muehlebach Hotel, Kansas City, Mo.
19–21	**Southwestern Gas Measurement Short Course,** Drill Hall, North Campus, University of Oklahoma.
20–22	**National Petroleum Association,** Semiannual Meeting, Hotel Cleveland, Cleveland.
20–22	**Texas A. & M. Symposium,** Instrumentation for the Process, College Station, Texas.
21–22	**ASME-SAM,** Management Conference, Statler Hilton Hotel, New York.
25–26	**ASME,** Maintenance and Plant Engineering Conference, Chase-Park Plaza, St. Louis.
25–29	**American Welding Society,** Annual Meeting and Welding Exposition. Los Angeles.
27–29	**NGAA,** Annual Convention, Rice Hotel, Houston.
May	
2– 6	**American Petroleum Institute,** Midyear Meeting, Safety and Fire Protection Committees, Atlanta-Biltmore Hotel, Atlanta.
9–12	**API,** Midyear Meeting, Division of Refining, Statler and Sheraton-Cadillac Hotels, Detroit.
9–13	**American Society for Metals,** Southwestern Metal Congress and Exposition, Sheraton and Other Hotels, Dallas.
22–26	**ASME,** Oil and Gas Power Conference and Exhibit, Muehlebach Hotel, Kansas City, Mo.
23–26	**Design Engineering Show,** New York Coliseum.
June	
5–10	**ASME,** Semi-Annual Meeting and Aviation Conference, Statler Hilton Hotel, Dallas.
5–10	**Society of Automotive Engineers,** Summer Meetings, Edgewater Beach Hotel, Chicago.
19–22	**AIChE,** Meeting, Del Prado Hotel, Mexico City.
26-Jul 1	**American Society for Testing Materials,** Annual Meeting and Apparatus Exhibit, Chalfonte-Haddon Hall, Atlantic City.
Aug.	
15–17	**ASME-AIChE,** Heat Transfer Conference and Exhibit, Statler Hilton Hotel, Buffalo, N.Y.
Sept.	
14–16	**National Petroleum Association,** Annual Meeting, Hotel Traymore, Atlantic City.
15–16	**ASME,** Engineering Management Conference, Hotel Morrison, Chicago.
18–21	**ASME,** Petroleum Mechanical Engineering Conference, Jung Hotel, New Orleans.
21–23	**ASME-AIEE,** Power Conference, Bellvue-Stratford Hotel, Philadelphia.
25–28	**AIChE** Meeting, Mayo Hotel, Tulsa.
25–28	**American Institute of Electrical Engineers,** Electrical Conference of the Petroleum Industry, Hotel Skirvin, Oklahoma City.
Oct.	
9–12	**ASME,** Rubber and Plastics Conference, Lawrence Hotel, Erie, Pa.
10–11	**ASME-AIEE,** Fuels Conference, Daniel Boone Hotel, Charleston, W. Va.
11–14	**National Association of Corrosion Engineers,** Northeast Region Conference, Prichard Hotel, Huntington, W. Va.
25–28	**NACE,** South Central Region Conference, Mayo Hotel, Tulsa.
Nov.	
27–Dec. 2	**ASME,** Annual Meeting, Statler Hilton Hotel, New York.

For more data on advertised products, use Readers' Service Cards, last page.

Gasoline Plant . . .

Built With An Eye To The Future!

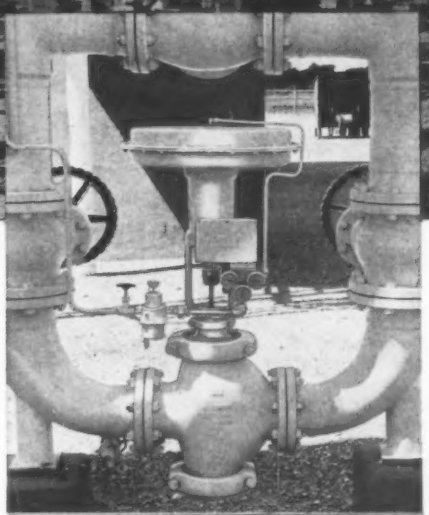
This modern absorption-type gasoline plant*, like most modern plants of today, was built with an eye to the future . . . with later expansion in mind.

Currently stripping 100 MMSCF of natural gas per day of propane, iso-butane, normal butane and natural gasoline, it can be quickly and inexpensively expanded to handle an additional 50% of its present capacity.

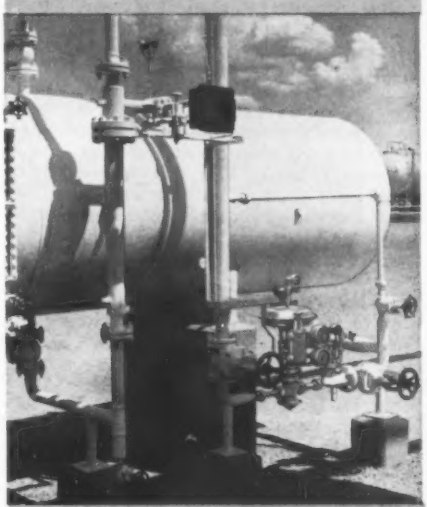
One very important reason for this plant flexibility was the incorporation in its design of wide range and capacity controls, such as BS&B Super 70 Control Valves, Liquid Level Controls and Regulators.

BS&B Controls are everywhere proving themselves in many different oilfield and other applications the world over. Why not specify them on your next job!

* Name and location supplied on request.



This 6", 150 lb. Super 70 serves as an accumulator pressure control valve. It is equipped with a direct acting actuator and valve positioner.



Butane splitter reboiler equipped with a BS&B Type 71-06 Series 2 Liquid Level Controller with automatic reset relay and a 1" Super 70 valve.

SUPER BS&B 70

BLACK, SIVALLS & BRYSON, INC.

Controls Division, Dept. 4-F2

7500 East 12th Street Kansas City 26, Missouri

For more data on advertised products, use Readers' Service Cards, last page.

Men In Industry...

Tobiasson

Conviser

George Tobiasson and Jack Conviser have attained the 40-year service mark with Universal Oil Products Co. Tobiasson is supervisor of the Catalyst Evaluation Laboratory and Conviser is manager of the Purchasing Department. Tobiasson joined UOP as a chemist and spent his first two years at the company's original laboratories in Independence, Kan. In 1921 he moved to the Riverside, Ill., laboratories, where he assisted in the development of thermal cracking. Conviser was the second draftsman hired by UOP. Shortly afterward he shifted to the Purchasing Department, where he has remained ever since, except for a brief period when he was in charge of distributing company publications.

Harold Bottomley, a petroleum consulting engineer in Tulsa, has been retained on a long-term contract by Treco Construction Division, Vitro Engineering Co. A former vice president of Treco from 1947-53, he has worked with petroleum refining and allied industries for more than 25 years. Bottomley started his career with Kanotex Refining Co., Arkansas City, Kan., where he was chief research chemist for five years. He was later chief chemist and then chief engineer for Cosden Petroleum Corp., chief engineer for Republic Oil and Refining Co., and assistant mechanical process engineer for Cities Service Oil Corp. During World War II, Bottomley was senior petroleum refining specialist with the Petroleum Administration for War, Washington, D.C. At Treco, he moved up from chief process engineer to vice president in charge of process design, estimating, and sales, the position he held before becoming a consultant.

W. G. Osborne has been named manager of the Natural Gasoline Division, Arkansas Fuel Oil Corp. He was formerly assistant to the division manager, and succeeds **M. F. Wirges,** named chief engineer. **W. H. Heyland,** former superintendent of operations, has been named assistant to the division manager. **J. E. Beavers,** formerly superintendent of the May plant, Kingsville, Texas, has been promoted to superintendent of operations, Shreveport. **M. R. Smith,** formerly construction engineer, Shreveport, has been promoted to May plant superintendent and transferred to Kingsville. All of the men have been with the company 10 years or more.

Charles D. Schnake, former supervisor of publications, Sunray Mid-Continent Oil Co., Tulsa, has been named public relations supervisor for the company. He will supervise all external public relations phases of the company's over-all program, including newspaper, trade journal, radio and television reporting, liaison with division-office public relations programs, oil industry public relations projects and community relations programs. Schnake joined Sunray in 1955 as editor of the employe publication. A past president of the Industrial Editors of Tulsa, he graduated from the University of Missouri School of Journalism in 1953. **Ronald L. Butterfield,** formerly a staff writer, has been named public relations representative. With Sunray since early 1959, he graduated from the University of Oklahoma in 1956 with a journalism degree.

Williams

Lapham

Lewis A. Lapham and Albert L. Williams have been elected to the board of directors, Socony Mobil Oil Co., Inc. Lapham is chairman of the Executive Committee, Bankers Trust Co., New York, and Williams is executive vice president and a director of International Business Machines Corp., New York.

R. B. Collins has been named superintendent of production for Neches Butane Products Co., Port Neches, Texas. Formerly the company's chief process engineer, he is a graduate of Texas A & M College in chemical engineering and has a M.S. degree from the University of Oklahoma. Other promotions include **F. R. Jelinek,** who holds a mechanical engineering degree from Purdue University, from chief engineer to superintendent of maintenance and engineering; and **H. D. Maples,** holder of a B.S. degree in chemical engineering from Texas A & M College, from chief chemist to superintendent of technical services. Replacing these men were **N. J. Vaglica,** a graduate of Texas A & M College in chemical engineering, from assistant chief process engineer to chief process engineer; **H. W. Kingsbery,** graduate in chemical engineering, Texas A & M College, from assistant chief engineer to chief engineer; and **J. N. Wilson,** holder of a B.S. degree in chemistry from the University of Alabama, from assistant chief chemist to chief chemist.

Dr. Richard A. Glenn, supervising chemist at Bituminous Coal Research, Inc., Pittsburgh, has been elected chairman of the Division of Gas and Fuel Chemistry, ACS, for 1960. He succeeds **Dr. R. Tracy Eddinger,** manager of the Eastern Gas and Fuel Associates' research laboratory, Boston. Dr. Glenn has a Ph.D. degree from The University of Texas. He has been a research chemist, Pittsburgh Coke and Chemical Co.; a staff member, coal research laboratory, Carnegie Institute of Technology; and a fellow at the Mellon Institute. **Joseph Grumer** of the U. S. Bureau of Mines, Pittsburgh, was named chairman elect, and **Dr. Robert S. Montgomery** of Dow Chemical Co., Midland, Mich., was elected secretary-treasurer. **Dr. Harlan W. Nelson** of the Battelle Memorial Institute, Columbus, Ohio, was chosen to represent the division on the ACS Council with **Dr. M. B. Bell** of Alcoa Research Laboratories, New Kensington, Pa., as alternate councilor.

W. C. Smith and Fred P. Sewell have been elected senior vice presidents, Delhi-Taylor Oil Corp. Formerly vice presidents in charge of specific operations, they will have broader areas of responsibility. Both will work closely with the president in developing company policy. In addition, they will operate as group vice presidents, coordinating operations and policies of the company's operating divisions. Smith was one of the original employes of Delhi Oil Corp., predecessor of Delhi-Taylor. Sewell joined Taylor Refining Co., the other Delhi-Taylor forerunner, in 1933.

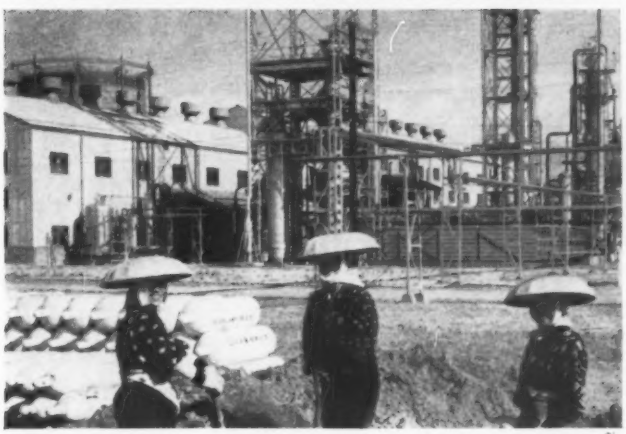
Allan L. Piper has been appointed manager of Tidewater Oil Co.'s Eastern Division Transportation and Supply Department and a member of the division's Operating Committee. He replaces **H. F. Tomfohrde,** named home office transportation manager, Los Angeles. Piper joined Tidewater in September 1937 as a mechanic's helper at Coalinga, Calif., and served as assistant field foreman, field engineer, and office engineer before becoming district supervisor of operations, Ventura, Calif., in 1941. He was Western Division office engineer from 1944-56, when he became assistant transportation manager, Western Division. Piper transferred to the Eastern Division in that capacity early in 1959.

Piper

Dr. Hugh H. Horowitz and William C. Howell, Jr., have been named research associates for Esso Research and Engineering Co. **Erwin H. Manny** has been named an engineering associate. All three men are in the company's Prod-

AMMONIA

NEW CHEMICO PLANTS TO BOOST WORLD CAPACITY 12½%



- 20 NEW PLANTS IN 7 COUNTRIES
- 8 NEW PLANTS IN THE U.S.A.
- 1,113,000 TONS PER YEAR

Since the first months of 1957, 13 new Chemico ammonia plants have been completed and put into operation. Another 7 Chemico plants are under construction or in the engineering stages. The design capacity of these 20 plants totals more than 1,000,000 tons per year.

Chemico's versatility in ammonia plant design is evidenced by the variety of raw materials on which these plants are based. While natural gas was the most common, crude oil, fuel oil and coke oven gas were also used. Regardless of feed stock, however, all thirteen of the operating plants were completed on schedule and started up without significant difficulties or delays. One plant, designed to produce 150 tons per day, took less than ten months to build, from initial go-ahead to completion of a satisfactory test-run.

This outstanding record in the ammonia field is just one of the reasons why chemical and petroleum companies all over the world continue to call on Chemico when they require ENGINEERING AT ITS BEST.

CHEMICO
CHEMICAL CONSTRUCTION CORPORATION
525 West 43rd Street, New York 36, New York

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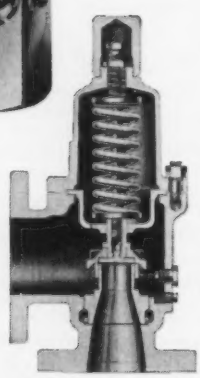
WORLD STANDARD FOR SAFETY

in process safety-relief valves

From the Near East to our own Far West . . . the name Farris on safety-relief valves has been a standard synonym for safety since 1943. The patented design features on all Farris full-nozzle valves combine to offer the ideal concept of a trouble-free, 100% safe safety-relief valve for every application.

2745


2950

SERIES 2600

The most popular top-guided, self-aligning, safety-relief valve for process piping service. Maximum pressure, 150 to 2500 psig, RF/RJ. Plain or Lever types. Standard or BalanSeal bellows construction.

SERIES 2740

A cast-steel relief valve of simplified design for use where extreme blow down accuracy is not essential, but where durability, compactness are. Pressures to 3500 psig at 450°F; 2000 psig at 800°F. Sizes ½" to 2".

SERIES 2745

An extremely rugged, compact, high pressure bar stock nozzle valve. Internal parts stainless steel. Adjustable blow down; flat seat; self-aligning stem and disc. Pressure to 10,000 psig. Sizes ½", ¾", 1".

SERIES 2950

A cast iron safety-relief valve including most of the exclusive Farris features found in the Series 2600. Max. pressure, 250 psig at 450°F, 400 psig at 150°F. Plain cap, open lever or packed lever types.

Complete information is provided in Catalog FE-118, covering both selection and sizing of Farris process Safety-Relief Valves. Send for your copy today.

PROGRESS THROUGH Farris HONEST PURPOSE

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Men . . .

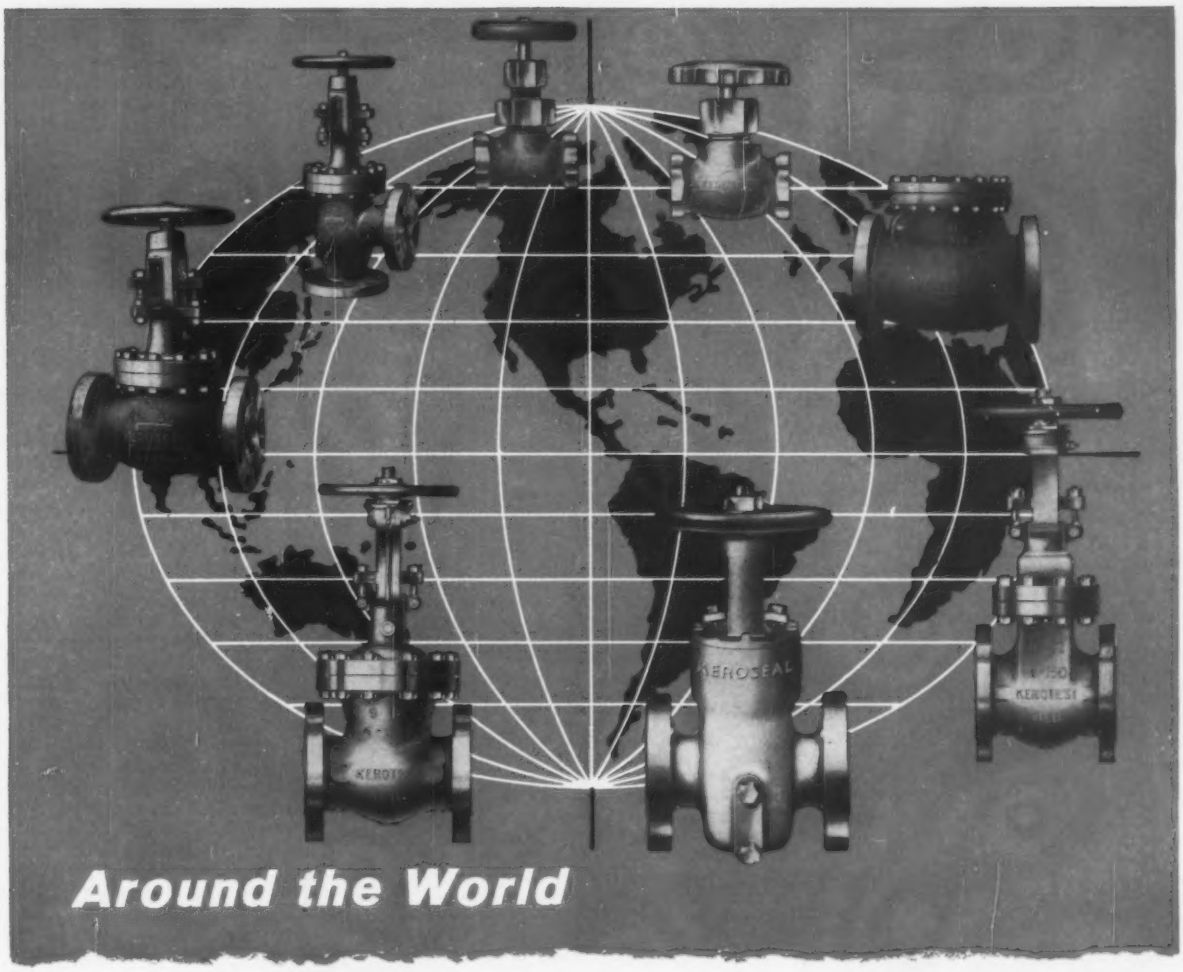
ucts Research Division. Dr. Horowitz, with Esso Research since 1952, holds a Ph.D. degree in organic chemistry from Columbia University. His research efforts have been primarily in the field of polymeric lubricating oil additives, and he has published several technical articles on the rheological properties of polymer solutions. Manny, with Esso Research since 1955, holds a degree in mechanical engineering from the University of Cincinnati, and since joining the company has concentrated on combustion problems. Howell, with the company since 1936, graduated from Wagner College with a B.S. degree in chemistry. He has worked in the firm's standard inspection laboratories, done research work on motor and aviation fuels and industrial lubricants, and has headed a group in charge of research and process oils.

James R. Anslow has been named senior research chemical engineer of Jefferson Chemical Co.'s Research Laboratories, Austin, Texas. Before joining Jefferson, he was with Magnolia Petroleum Co. as a gas engineer, Monsanto Chemical Co. as a production supervisor, and Escambia Chemical Co. as process development manager. Anslow attended Heidelberg College and the University of Cincinnati, and received his degree in chemical engineering from Texas Technological College.

Anslow

Dr. L. I. Griffin, Jr., assistant director, Esso Research Laboratories, Baton Rouge, La., has been given responsibility for patents and technical information. He succeeds **Dr. John J. Owen,** who has retired. Dr. Griffin also will continue his work in fuels research and development. In other changes at the laboratories, **W. W. Boisture** has been named personnell and business manager, and **Dr. L. E. Swabb,** formerly responsible for business and personnel matters, will manage petroleum processes and applied mathematics. **Dr. M. M. Lambert,** formerly on loan to Esso's Baton Rouge refinery, will head the Personnel and Research Effectiveness Section. **W. J. Porter, Jr.,** formerly head of the section, will head a chemicals section.

John A. Parsons has been named president of American Plastics Corp., and **Elmer G. Smith,** executive vice president. Parsons, formerly executive vice president, has also served as a director and was vice president in charge of production for many years. In the plastics industry more than 40 years, he has been active in the Society of Plastics Industry and the Society of Plastics Engineers. Smith, named vice president of the company early in 1959, has been American Plastics' sales manager, and has 15 years



. . . and 50 Years of quality VALVES

Visit oil and gas industries, processing and other industrial plants in any country in the world and you will find Kerotest Valves at work in a multitude of jobs. This universal acceptance of Kerotest Valves is the result of a continuous effort toward product improvement ever since the company was founded in 1909.

Around the world and 50 years later, Kerotest still continues to make highest quality valves, with consistent effort toward even greater product improvement. Each step in Kerotest Valve manufacture, from raw materials to final rigid inspection, is the result of research and engineering directed solely to obtaining better product performance on the job. The results of these efforts have set Kerotest Valves apart from the ordinary and have maintained their high standards of quality everywhere.

For additional information on valves for your requirements, write today for the latest Kerotest brochure.

KEROTEST QUALITY VALVES FOR EVERY REQUIREMENT

- Gate Valves
- Globe Valves
- Angle Valves
- Check Valves
- Pipe Line Valves
- Positive Shut-Off Valves
- Production Valves
- Needle Valves
- Well Head Equipment
- General Purpose Valves
- Special Valves

KEROTEST MANUFACTURING COMPANY

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KEROTEST

BURRELL *"For Scientists Everywhere"*

UNIFORM SOLUTIONS
For Gas Analysis

always fresh and active
. . . order as you need

Modern Burrell Reagents and Auxiliary Solutions are available as a regular, dependable source of supply for use with all makes of gas analysis equipment.

Listed here are some perennial "best sellers." Tell us your needs for prompt service.

Fast Absorbing Reagents

COSORBENT® for Carbon Monoxide. Active and accurate. Forms stable compound. Requires few passes.
CAT. No. 39-720—8 oz. 6.00.....Case of 12—64.80
CAT. No. 39-721—3 oz. 3.25.....Case of 12—35.10

COSORBENT POWDER for Carbon Monoxide. Easier to store and transport. Has indefinite shelf life.
CAT. No. 39-725—vial 3.85.....Case of 12 vials—41.60

LUSORBENT® for Unsaturated Hydrocarbons. No vapor pressure. Non-Corrosive to rubber connections.
CAT. No. 39-715—8 oz. 4.40.....Case of 12—47.55
CAT. No. 39-716—3 oz. 2.75.....Case of 12—29.70

OXSORBENT® for Oxygen. Fast, clean and accurate. Breaks sharply at saturation point.
CAT. No. 39-710—8 oz. 6.00.....Case of 12—64.80
CAT. No. 39-711—3 oz. 3.25.....Case of 12—35.10

DISORBENT® for Carbon Dioxide. Crystal clear potassium hydroxide solution. Accurate and fast.
CAT. No. 39-730—16 oz. 3.25.....Case of 12—35.10
CAT. No. 39-731—3 oz. 1.90.....Case of 12—20.55

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NOTE: Order 8 oz. for each charge in a standard absorption pipette; 3 oz. for Industro® gas analyzers.

Specifics for Hydrocarbons

SORBENT "A"™—For total olefins, ethene, propene, butene and pentenes.
CAT. No. 39-741—8 oz. 5.00.....Case of 12—54.00

SORBENT "B"™—For selective absorption of iso-butene. Takes up 1-butene and 2-butene slowly.
CAT. No. 39-742—8 oz. 3.00.....Case of 12—32.40

SORBENT "C"™—For propenes, butenes and pentenes. Will absorb ethene slowly.
CAT. No. 39-743—8 oz. 3.00.....Case of 12—32.40

SORBENT "D"™—For acetylenes and higher members of the acetylene series.
CAT. No. 39-744—8 oz. 6.50.....Case of 12—70.20

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Prices listed are F. O. B. Pittsburgh, Pa.

Ask for Bulletin No. 327

BURRELL CORPORATION
Scientific Apparatus and Laboratory Supplies
2223 FIFTH AVENUE, PITTSBURGH 19, PA.

Men . . .

experience with Heyden Newport Chemical Corp. in various sales, development and production functions. He holds B.S. and M.S. degrees from Lehigh University.

Mark E. Houser, director of manufacturing, Wilshire Oil Co. of Calif., has been elected vice president, manufacturing. In addition to management of Wilshire's 35,000-bpd Santa Fe Springs, Calif., refinery, Houser has full responsibility for the Pipeline Department and coordinates economic research in connection with both present and future operations. A graduate of the University of Minnesota, Houser has been in the oil industry for the past 16 years.

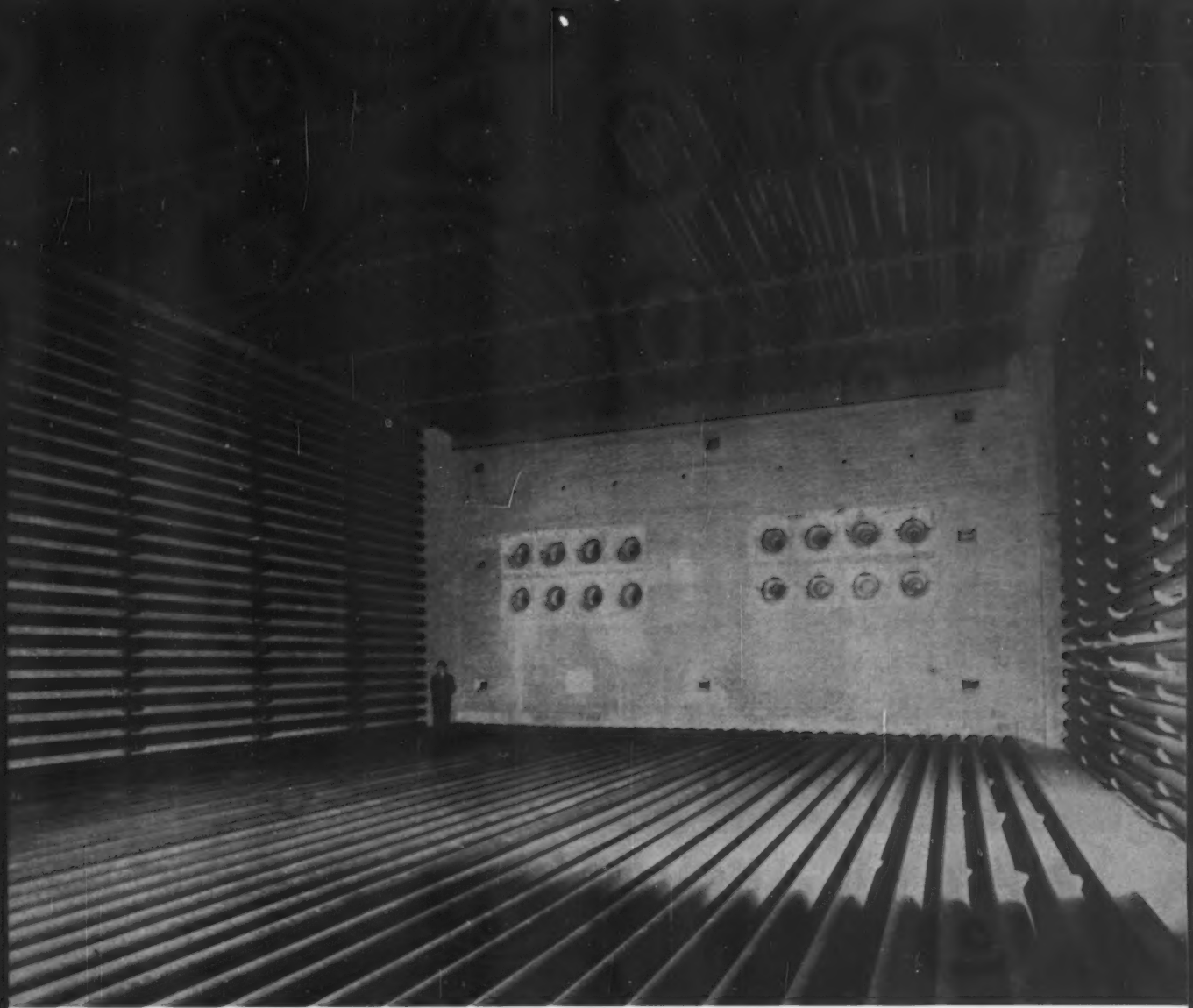
Houser

Walter O. Miller has been named superintendent of Continental Oil Co.'s new oxo alcohol plant, currently under construction at Lake Charles, La. He had been superintendent of the company's Baltimore, Md., petrochemical plant. Other promotions include **T. J. Karolenko,** superintendent of the Chicago and Hammond, Ind., petrochemical plants, promoted to plant superintendent, Baltimore; **J. H. McGinnis,** assistant superintendent, Chicago plant, promoted to superintendent, Chicago and Hammond plants; and **E. J. Karwacki,** Hammond, who becomes assistant superintendent, Chicago and Hammond plants.

William A. Dennison has been named to succeed **Fred Van Covern** as director of the Department of Statistics, API. Currently manager of the Economic Research Section of API's Committee on Public Affairs, he will be replaced in his former post by **Peter Griskivich,** assistant manager of the section. Dennison graduated from Trinity College, Dublin, Ireland, in 1919. His background is in business economics.

Virgil A. Romito has been named director of production for Allied Chemical Corp.'s General Chemical Division. Until his appointment in 1958 as maintenance manager, Romito had been plant manager of the North Claymont, Del., plant for five years. He joined the firm in 1933 as a draftsman, later serving in varied production, engineering and maintenance posts in company plants. He graduated from Carnegie Institute of Technology with a B.S. degree in mechanical engineering in 1932.

R. B. Robitaille, who has been manager of Phillips Chemical Co.'s Eastern District rubber chemicals sales, Providence, R. I., is moving to Milan, Italy, as managing director of Phillips Carbon



Why so big?

This direct-fired Foster Wheeler heater is one of the world's largest for sound economic reasons. It serves a 125,000 bbl/day crude distillation unit at Gulf Oil Corporation's Girard Point refinery.

Although Foster Wheeler engineers put this heater into service several years ago, very few direct-fired heaters built since can match either its size... 284,075,000 Btu/hr absorbed—or performance . . . six full years of reliable, trouble-free operation.

Remember this example of FW heater know-how the next time you are faced with the problem of specifying a process heater.

Consider the assistance FW engineers can offer. You will find them both ingenious and practical in providing a heater tailored to your process *and to your budget.* Backed by 40 successful years of direct-fired heater design and construction, FW engineers give you the best in equipment performance and reliability.

FW can furnish you with a full line of both vertical and horizontal heaters to meet the widest possible range of process requirements. Contact Foster Wheeler Corporation, Department B, 666 Fifth Avenue, New York 19, N. Y.

Heat Engineered products, plants and processes . . . for the world's industrial progress.

FOSTER FW WHEELER

NEW YORK LONDON PARIS ST. CATHARINES, ONT.

R-P&C Lubrotite Valves
end double valving... cut valve costs

• Illustrated above is a lubricated gate valve designed for use in HF Alkylation service.

Here are some advantages you get when you install R-P&C Lubrotite Gate Valves to handle gasoline, oil, benzol, HF Alkylation and other critical fluids:

1. **Positive tightness.** Properly lubricated valve *remains tight* even if seat is damaged by foreign matter in line.
2. **Protection from corrosion.** In the unique Lubrotite system, the lubricant retards corrosion, prevents sticking and leakage, makes for easier operation.
3. **Ends need for double valving.** Lubricant forms more positive seal and gives better shut-off than double installation or regular gate valves.
4. **Factory testing.** Lubrotite valves are factory-tested, without lubricant, before shipment.
5. **Versatility.** Suitable for gas, air, water, certain chemicals, and many other fluids.
6. **Double economy.** Lubrotite gate valves not only help reduce your operating costs; they cut replacement costs, too.

A FULL VALVE LINE

R-P&C Distributors offer users in the petroleum industry a complete line of R-P&C valves in all standard materials—plus many specialties. See your nearest R-P&C Distributor—or write

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R-P&C Valve Division, American Chain & Cable Company, Inc.

Reading, Pa., Atlanta, Boston, Chicago, Denver, Detroit, Houston, New York, Philadelphia, Pittsburgh, San Francisco, Bridgeport, Conn.

Men . . .

Black Italiano. He joined Phillips in 1944 and has been in Providence as Eastern District representative, Rubber Chemicals Sales Division, since 1952.

David X. Klein, technical director of Heyden Chemical Division, Heyden Newport Chemical Corp., has been appointed a divisional vice president. Technical director for the division since June 1959, he has been responsible for its expansion and new products program. He was formerly manager of research at the company's Garfield, N. J., laboratories. Klein began his professional career with the Organic Chemicals Division of E. I. du Pont de Nemours & Co. in 1930, and during World War II, engaged in research on the "Manhattan Project." He is active in several professional societies.

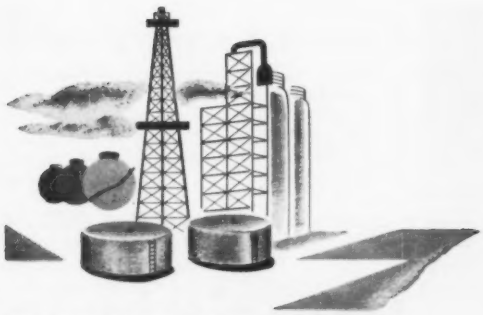
Klein

Ronald A. Baker has been named assistant manager, Technical Service Division, of Mobil Oil Co.'s Research Department, New York. He joined General Petroleum Corp., a part of Mobil Oil, 27 years ago. Baker was previously manager of the Technical Department in General Petroleum's Manufacturing Department. He has also been a junior inspector, Process Laboratory, Torrance, Calif.; senior chemical engineer, superintendent of laboratories, Torrance; manager of the laboratories at Vernon, and assistant to the manager, Manufacturing Department. Baker received his B.S. degree in chemical engineering from the University of California.

Carl H. Samans has been elected chairman of the Chicago Section, American Institute of Mining, Metallurgical, and Petroleum Engineers. He is director of the Engineering Materials Division, Research and Development Department, Standard Oil Co. (Indiana). Since he joined Standard in 1949, Dr. Samans has carried out and directed studies on metals, ceramics, insulating materials, protective coatings, and refractories. Other societies in which he is active are: ASM, NACE, AWS, API, and the Institute of Metals (London). He has a B.S. degree in chemical engineering from Rensselaer Polytechnic Institute, and M.S. and Ph.D. degrees in metallurgy from Yale University.

Raymond A. Reinke has been promoted to vice president in charge of Continental Carbon Co.'s International Division. Formerly manager of commercial development, he will headquarter in Amarillo, Texas. Reinke is a graduate of the University of Chicago, where he majored in chemistry. He joined Continental Carbon in 1944 as a chemist at the Sunray, Texas, laboratory, and has

For more data on advertised products, use Readers' Service Cards, last page.



PETROLEUM INSTALLATIONS

STOP WEEDS

with safe, effective

SIMAZINE or ATRAZINE

pre-emergence *pre- or post-emergence*

HERBICIDES

Economical, long residual Geigy herbicides save time and money—do the job right the first time. One application stops weeds before they start—gives you season long control.

Safe to humans and animals, non-irritating to skin, non-flammable, non-corrosive to equipment. Safe to use on valuable land. Available through leading distributors.

FREE BROCHURE:
New full color booklet contains complete directions, diagrams, applications and other useful data for both Simazine and Atrazine.

Geigy *ORIGINATORS OF DDT INSECTICIDES*

MAIL COUPON TODAY

GEIGY AGRICULTURAL CHEMICALS,
Division of Geigy Chemical Corporation
Saw Mill River Road, Ardsley, N.Y., Dept. PR-2

Send free weed control brochure to:

*Name*_____

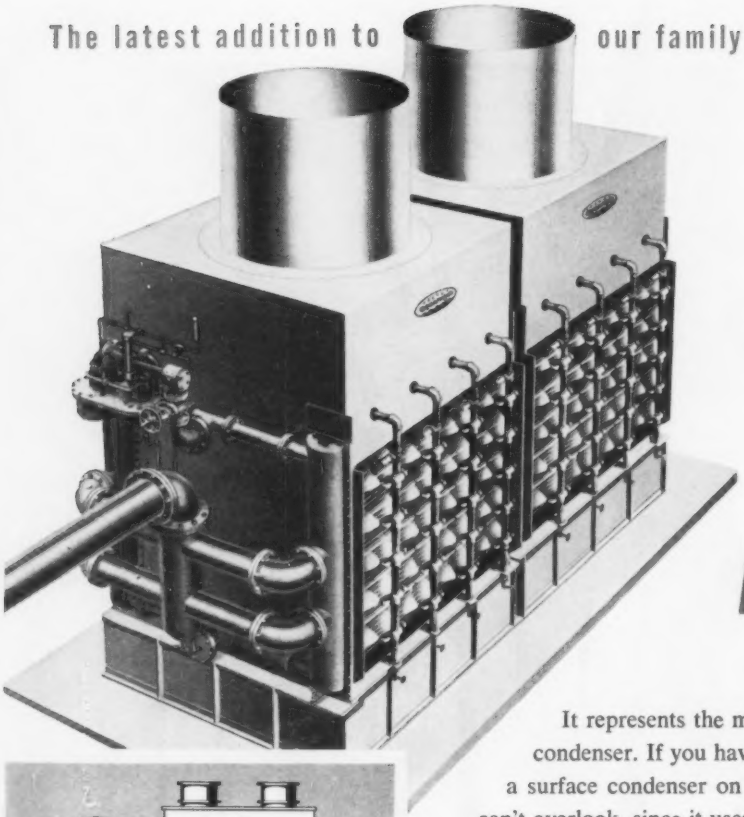
*Company*_____ *Position*_____

*Address*_____

*City*_____ *State*_____

For more data on advertised products, use Readers' Service Cards, last page.

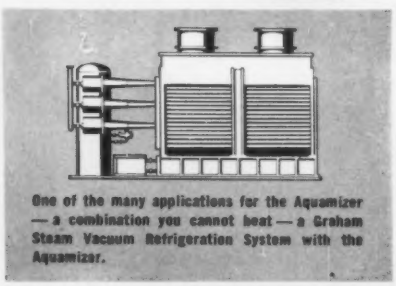
The latest addition to our family of tried and proven products



Here it is— the Aquamizer®

It represents the most modern concept of an evaporative condenser. If you have a cooling water problem and require a surface condenser on any vacuum system, it's an item you can't overlook, since it uses no external source of water.

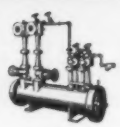
And—if you want really cold water—we offer you a Steam Vacuum Refrigeration System equipped with an Aquamizer. Here is a means of providing large quantities of cold water down to 35°F and, as stated above, requires no external source of cooling water. No expensive refrigerants—no compressor—no extensive maintenance!



One of the many applications for the Aquamizer — a combination you cannot beat — a Graham Steam Vacuum Refrigeration System with the Aquamizer.

Other Graham Precision Built Products

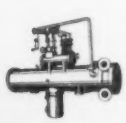
HELIFLOW HEAT EXCHANGERS



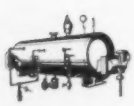
STEAM JET EJECTORS

BAROMETRIC CONDENSERS

MONOBOLT HEAT EXCHANGERS



SURFACE CONDENSERS



EVAPORATORS

DEAERATING HEATERS

STEAM VACUUM REFRIGERATION

GRAHAM MANUFACTURING CO., INC.

Heliflow Corporation

170 GREAT NECK ROAD • GREAT NECK, NEW YORK

Offices in principal cities and Canada

Men . . .

since held key positions in plant operations, technical and customer relations, and administration. He will remain in charge of commercial development, with the additional responsibility of international operations.

Dr. Rush F. McLeary has been elected vice president for research and development, Jefferson Chemical Co., Inc., Houston. He will also be responsible for expanding activities in customer technical service and product application. Holder of M.S. and Ph.D. degrees in chemistry from Purdue University, he joined Texaco, Inc., in 1940, serving in various chemical research positions with the Research and Technical Department, Beacon, N.Y. He joined Jefferson in 1956 as general manager, Research and Development Department.

McLeary

Dr. Franklin Veatch has been named research director in charge of petrochemicals, polymers and new processes at the Sohio Research Center, Warrensville Heights, Ohio. He has been with Sohio since 1942. A graduate of the University of Arizona, he has a Ph.D. degree in organic chemistry from Stanford University. As the leader of Sohio's petrochemical research team, Dr. Veatch has recently guided research on acrylonitrile, which the company is commercializing in a 50 million-pound-per-year plant at Lima, Ohio.

J. A. Boege has been named manager of technical services at Mobil Oil Co.'s Torrance, Calif., refinery. He joined General Petroleum Corp., a part of Mobil Oil, in 1930. He will be responsible for engineering, economics and planning, and the control laboratory. **J. W. Jensen,** just named chief project engineer at the Torrance refinery, joined General Petroleum in 1940. He will be responsible for design, mechanical, and project engineering.

Leland W. Carter has been assigned to Delhi-Taylor Oil Corp.'s Special Projects and Planning Division. He joined the company as gas engineer in the Natural Gas and Pipeline Department. Carter graduated from the University of Tulsa with a B.S. degree in petroleum engineering in 1950, and from Southern Methodist University with a law degree in 1958. He formerly worked as a gas engineer and patent attorney for The Atlantic Refining Co., Dallas.

Jack Raglin has been named assistant director of public affairs, Continental Oil Co., Houston. He formerly was administrative assistant to the company's president. Raglin joined Conoco's Industrial

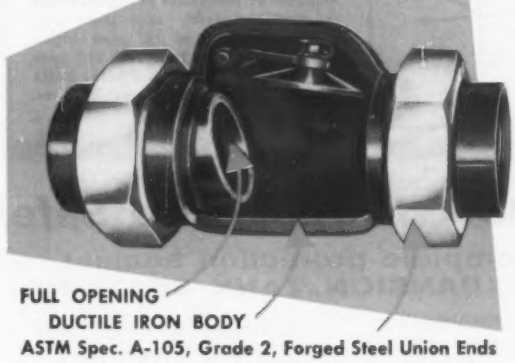
NEW DUCTILE IRON BODY

CATAWISSA "502" CHECK VALVES

1000 psi OWG 3000 psi Test
Sizes: 2" thru 4" N.P.T.

- COMPACT
- EFFICIENT
- ACCESSIBLE
- EASY TO INSTALL
- EASY TO INSPECT

for general flow line and pipeline use . . . horizontal or vertical



FULL OPENING
DUCTILE IRON BODY
ASTM Spec. A-105, Grade 2, Forged Steel Union Ends

Here is one valve designed to take the rough handling necessary in most applications!

Metallographic structure of the ductile iron body resists leakage or seepage of liquids or gases.

In production, pipeline or refinery use—the "502" has earned a reputation for long-life service and satisfaction . . . and now it's a better valve, a better buy than ever!

Catawissa "502" Check Valves withstand severe service conditions with built-in resistance to wear, shock or elevated temperatures. Their resistance to oxidation and a wide variety of corrosive media make them especially valuable where corrosion is a factor. Get the full story on all of their extra-value features!

There's no need to "beat a path to our door" . . . just write for Catalog 58 or call your favorite supply store!

1917 42 1959
YEARS OF DEPENDABILITY

CATAWISSA VALVE & FITTINGS CO.

CATAWISSA • PENNSYLVANIA

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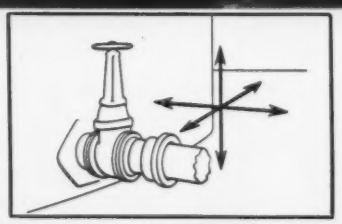
Unlimited Flexibility!
—PROVEN IN SERVICE

Left—Cross-section shows construction of Barco Flexible Ball Joint.



Allows 6-Way Movement!

Freedom of movement in any direction is readily possible with these *ball joint connections* of 12" pipe (right) and 8" pipe (left) to 80,203 bbl. tank shown in above photo. (Photo: SHELL OIL COMPANY, Dominguez Refinery, Wilmington, Calif.)

Barco Ball Joints—*Fire Safe!*

provide complete protection against FIRE, PIPE EXPANSION, TANK SETTLING

Major oil companies throughout the country now approve the use of Barco's new large size Flexible Ball Joints on tank connections for the following reasons:

1. Fire-safe. The joints have passed rigid fire and water spray tests.
2. Superior for handling pipe expansion—no combustible packing, no thin wall sections, no "end thrust" from pressure, no heavy pipe anchoring required.
3. Complete protection—relieve strain and twisting forces on valve flanges or tank wall.
4. Compact! Ideal for use inside narrow space between fire wall and tank. Easy to design piping for any amount of flexibility desired.
5. Also useful for insulating piping against electrolysis.
6. Long service life without maintenance. No lubrication. Sizes to 16"; flanged or welding ends.

For engineering recommendations, see your nearest Barco representative or write. ASK FOR CATALOG 215B and BULLETIN 31-A.

PRODUCTS BACKED BY EXPERIENCE BARCO FOUNDED 1918

BARCO MANUFACTURING CO.
542C Hough Street • Barrington, Illinois

The Only Truly Complete Line of Flexible Ball, Swivel, Swing and Revolving Joints
In Canada: The Holden Co., Ltd., Montreal

Men . . .

Relations Department, Houston, in 1951 as editor of employe publications, and was promoted to director of the Employe Communications Division in 1954. Administrative assistant to the president since early 1956, he has a journalism degree from the University of Missouri. In the oil industry since 1934, he edited publications for Sun Oil Co., Philadelphia, and Phillips Petroleum Co., Bartlesville, before joining Conoco.

Robert D. Bent has been elected a director and vice president of The Atlantic Refining Co. He will continue as general manager of the Manufacturing Department. Bent fills the unexpired term of **W. F. Stroud,** who retired from active management of the company in June and has resigned as a director. Bent joined Atlantic in 1935 and served with the firm's Research and Development Department until 1958 when he was named manager, Technical Service Department of Manufacturing. In February 1959, he was promoted to assistant general manager of manufacturing and in June, was named general manager.

Bent

T. Cortlandt Williams has been named chairman of the board, Stone & Webster Engineering Corp. **Fred W. Argue,** executive vice president, was elected president succeeding Williams. **Alfred L. Hartridge,** financial vice president and treasurer, becomes executive vice president, and **Dr. Arthur J. Good,** currently vice president and comptroller, is the new vice president and treasurer. Williams has been with S & W since 1923, Argue since 1941, Hartridge since 1931 and Dr. Good since 1951.

A. H. Knoll, Proctor and Gamble Co., Cincinnati, has been appointed chairman of the Mechanical Technical Committee, Manufacturing Chemists' Association. He succeeds **D. F. Hollingsworth** of E. I. du Pont de Nemours & Co. Knoll received his M.S. degree in chemical engineering in 1931, and the same year joined Proctor and Gamble. He was appointed head of the Factory Service Department in 1953. Knoll is also chairman of the B-78 Sectional Committee, ASA, which will prepare standards for heat exchangers for chemical industry use. Vice chairman of the Mechanical Technical Committee will be **P. J. Callan,** Eastman Kodak Co., Rochester, N. Y.

Bernard Kaapcke, special feature editor on AGA's public information staff for the past three years, has been named editor of the *AGA Monthly* succeeding **Walter H. Dyer,** who has resigned. Kaapcke's duties at AGA have included a wide variety of writing and editing

For more data on advertised products, use Readers' Service Cards, last page.

PROBLEM: An effective solid catalyst was sought for the alkylation of isobutane with ethylene to produce diisopropyl, a high octane gasoline component valuable for its high lead susceptibility and excellent volatility.

SOLUTION: Use of BF_3 with certain hydrated salts produces active alkylation catalysts which bypass many problems encountered with known catalysts. These new catalysts can be used at low temperatures—thus avoiding undesirable side reactions and mixing problems due to changes in viscosity.

NEED A BETTER CATALYST?

INVESTIGATE B&A® *BORON TRIFLUORIDE*

The versatility of boron trifluoride and its cost-cutting advantages make it a catalyst to be considered in almost any organic synthesis problem. The use of BF_3 as an alkylation catalyst in the preparation of diisopropyl (described above) is an excellent recent example. The next synthesis problem BF_3 will help solve may well be *yours!*

Here are some of the reactions catalyzed by BF_3: polymerization, alkylation, esterification, nitration, sulfonation, halogenation, isomerization, arylation, cyclization, hydration, acylation, and there are more!

Baker & Adamson has long been the leader in BF_3 research and production. We were the first to introduce boron fluoride etherate to industry. We pioneered in shipping the compressed gas by tube trailer transport—making it readily available in large commercial quantities. Steady, dependable supply is assured when you call on B&A for boron trifluoride.

Write today—for technical data on the properties and typical uses of B&A Boron Trifluoride gas or any of its complexes listed. Attach company letterhead, please.

- Boron Trifluoride, Di-acetic Acid Complex
- Boron Trifluoride, Di-n-Butyl Ether Complex
- Boron Trifluoride, Dihydrate (Stabilized)
- Boron Trifluoride, Ether Complex, Tech.
- Boron Trifluoride, Ethyl "Cellosolve" Complex
- Boron Trifluoride, Hexamethylene-tetramine Complex
- Boron Trifluoride, Monoethylamine Complex
- Boron Trifluoride, Monohydrate
- Boron Trifluoride, Para-cresol Complex
- Boron Trifluoride, Phenol Complex, Tech.
- Boron Trifluoride, Piperidine Complex
- Boron Trifluoride, Triethanolamine Complex
- Boron Trifluoride, Urea Complex

BAKER & ADAMSON®
Fine Chemicals

Allied Chemical

GENERAL CHEMICAL DIVISION
40 Rector Street, New York 6, N.Y.

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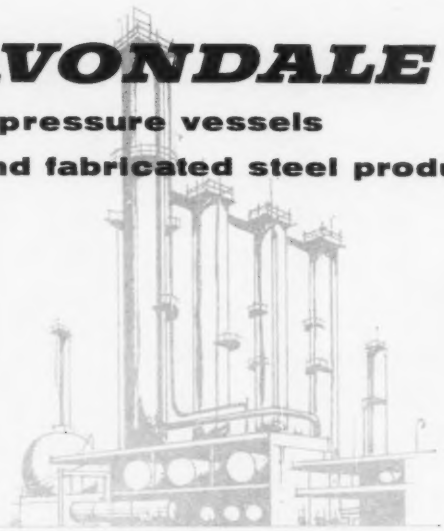
AVONDALE

builds pressure vessels and fabricated steel products



From its strategic location on the Mississippi River Avondale can build and ship pressure vessels and fabricated products of a size and weight to suit almost any job requirement.

Avondale invites your inquiry regarding your particular needs in this specialized field of steel fabrication.

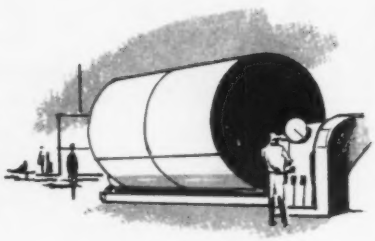
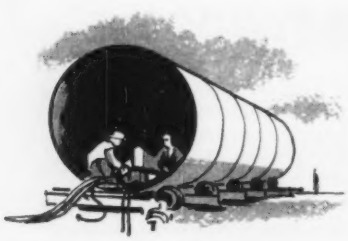
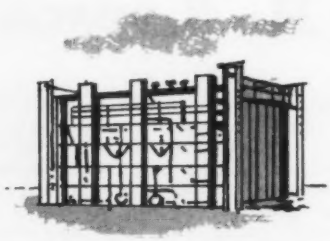


Plate rolls will accept any thickness up to 4½"



Automatic welding of longitudinal seam in pressure vessel



Stress relieving furnace with temperatures up to 2100° F.

VERSATILE BUILDER ON THE MISSISSIPPI

AVONDALE

MARINE WAYS, INC.

Industrial Division

P. O. BOX 1030 • UNiversity 6-4561 • NEW ORLEANS 8, U. S. A.

Men . . .

assignments, including preparation of the association's annual reports. Before joining AGA in 1956, he was an editor-writer for Kaiser Industries company magazines in Oakland, Calif. He began working for United Press while earning a B.A. degree at the University of Washington. After graduation, he continued as a newsman in UP's Seattle and San Francisco bureaus.

Edward D. Loughney has been named president and chief executive officer of The British American Oil Co., Ltd. **E. D. Brockett,** B-A president since April 1958, has been named executive vice president of Gulf Oil Corp., Pittsburgh. Loughney, a B-A senior vice president since November 1957, came to the United States in 1951 to head Canadian Gulf Oil Co., Calgary. From 1951-56, he was responsible for production and exploration operations in Western Canada as vice president and general manager of Canadian Gulf. Since B-A's acquisition of Canadian Gulf in 1956, he has had corporate responsibilities for the company as a vice president and director.

Loughney

Francis X. Owens has been named training supervisor of Tidewater Oil Co.'s Eastern Division. A Tidewater employee since 1930, he will have responsibility for the guidance of all training programs carried out in the division. Owens joined Tidewater as a clerk, New York Office, in 1930. After holding varied positions in the company, he became sales training supervisor in 1955.

Dr. Vincent L. Hughes has been named head of a new section in the Chemicals Research Division, Esso Research and Engineering Co. The new unit's work will focus on chemicals process work. Dr. Hughes has been with Esso Research since 1955. Holder of B.S., M.S. and Ph.D. degrees in physical chemistry, he is the author of several publications in that field, and is a member of ACS.

Alexander F. Imlay has been named secretary-treasurer for Esso Standard Oil Co. succeeding **Lester R. Moore,** treasurer of Humble Oil & Refining Co. (Delaware). Imlay will head two separate departments at Esso's New York City headquarters. He has been an assistant treasurer since 1956, and served earlier as assistant to the treasurer of Jersey Standard.

Howard Payne, assistant general manager of construction for Brown & Root, Inc., has been made a vice president. With Brown & Root since 1937, he has just returned from a 30-day inspection trip of a Brown & Root project in Thailand. For two years he has been

For more data on advertised products, use Readers' Service Cards, last page.

built by Badger for

ATLANTIC

220 million lb/yr. wax plant of advanced design completed in 61 weeks

One of the largest, most flexible wax manufacturing plants ever constructed has recently been completed by Badger at the Atlantic Refining Company's Philadelphia refinery. The classic and widely used MEK solvent process* was the starting point for this ultra-modern plant. From there, Badger engineers created an unusually versatile design . . . a plant capable of processing eight different feedstocks through fourteen operations to produce corresponding grades of paraffin waxes (oil content 0.2%).

Plant capacity (265 tons/day) and the number and variety of processing steps made economical design a major engineering undertaking. Examples: the filter section includes fourteen 700 sq. ft. units of an improved design — the largest in the petroleum industry; the two compressors in the massive refrigeration section have a combined rating of 5,800 h.p. — equivalent to the capacity required to produce 4,200 pounds of ice per minute; the chiller-exchanger section consists of 33 units (sixteen scraped-pipe exchangers, seventeen scraped-pipe chillers) in a novel arrangement that simplifies maintenance and operation.

In spite of its size and the complexity of the engineering problems involved, Badger completed Atlantic's plant in less than fourteen months. This project is another example of how Badger engineering skill helps leading companies get more efficient, economical plants. Isn't this the type of service you deserve?

New 8-page brochure describing the Atlantic Wax Manufacturing Plant available on request. Write for your copy.

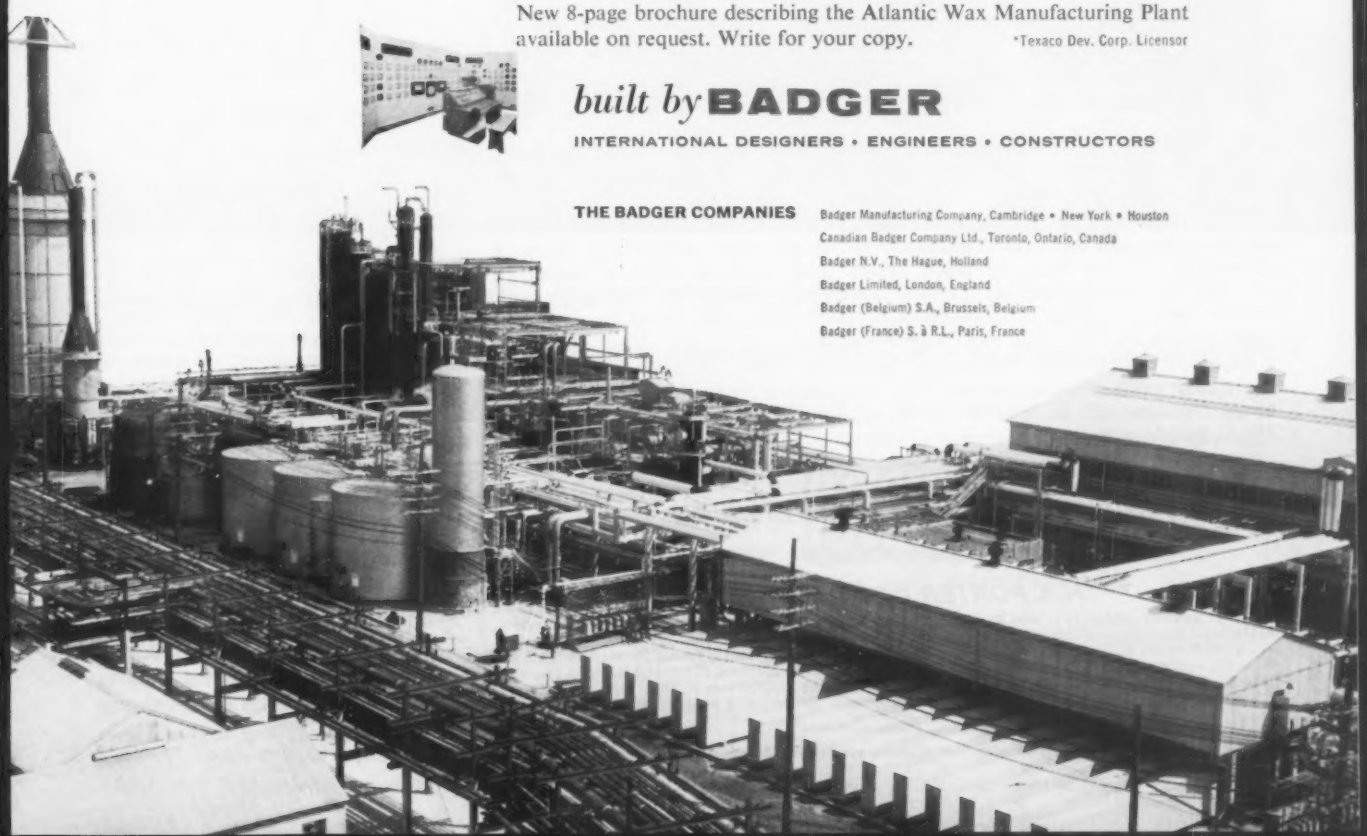
*Texaco Dev. Corp. Licensor

built by **BADGER**

INTERNATIONAL DESIGNERS • ENGINEERS • CONSTRUCTORS

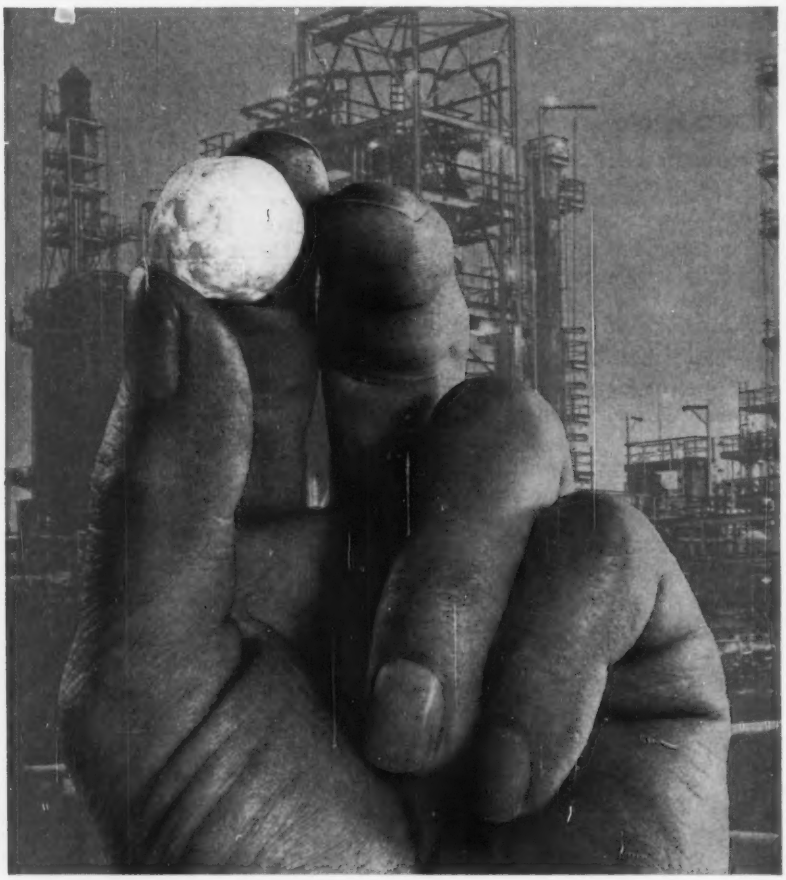
THE BADGER COMPANIES

Badger Manufacturing Company, Cambridge • New York • Houston
Canadian Badger Company Ltd., Toronto, Ontario, Canada
Badger N.V., The Hague, Holland
Badger Limited, London, England
Badger (Belgium) S.A., Brussels, Belgium
Badger (France) S. à R.L., Paris, France



FOR CATALYST BED SUPPORT:

This Porter Mullite Pellet costs up to 50 per cent less!



Porter Mullite Pellets actually do cost up to 50 per cent less than most catalyst bed support materials now available. *And you make no operational sacrifice to gain this savings!*

Porter mullite pellets have been commercially tested for over three years, as inert support for active catalyst, in many major refineries. They've withstood all the trials of heat, shock and pressure without breaking or dusting. Porter mullite pellets have successfully resisted abrasion, erosion and crushing . . . completely protecting the valuable catalysts from contamination.

Convert to Porter mullite pellets now, and reflect these important cost-savings in your refining process. For complete information, write: *Refractories Division, H. K. Porter Company, Inc., Porter Building, Pittsburgh 19, Pennsylvania.*

REFRACTORIES PORTER DIVISION

H.K. PORTER COMPANY, INC.

PORTER SERVES INDUSTRY: with Rubber and Friction Products—THERMOID DIVISION; Electrical Equipment—DELTA-STAR ELECTRIC DIVISION, NATIONAL ELECTRIC DIVISION, PEERLESS ELECTRIC DIVISION; Specialty Alloys—RIVERSIDE-ALLOY METAL DIVISION; Refractories—REFRACTORIES DIVISION; Electric Furnace Steel—CONNORS STEEL DIVISION, VULCAN-KIDD STEEL DIVISION; Fabricated Products—DISSTON DIVISION, FORGE AND FITTINGS DIVISION, LESCHEN WIRE ROPE DIVISION, MOULDINGS DIVISION, H. K. PORTER COMPANY de MEXICO, S. A.; and in Canada, Refractories, "Disston" Tools, "Federal" Wires and Cables, "Nepcoduct" Systems—H. K. PORTER COMPANY (CANADA) LTD.

Men . . .

assistant to **Louis H. Durst,** general manager of construction, operating out of the Houston office.

Joseph Stewart has been named an assistant director in the Chemicals Research Division, Esso Research and Engineering Co. A Chemist, he has been with the company since 1945. Stewart has a B.S. degree in chemistry from Long Island University, and a M.S. degree from Purdue University. He is a member of ACS and AIChE.

John S. Sprowls, vice president and assistant to the president, The Vickers Petroleum Co., Inc., has been elected to the company's board of directors. Formerly assistant treasurer in charge of loans and related investments, Gulf Oil Corp., Pittsburgh, Sprowls joined Vickers last September. He is in charge of long range financing programs and investments.

Francis Boyer, chairman of the board of Smith, Kline & French Laboratories, has been elected to the board of The Atlantic Refining Co. He has been with Smith, Kline & French since 1919, serving as assistant to the president, executive vice president, and president before becoming chairman of the board. He also is a director of Pennsalt Chemicals Co.

William F. Kirk, manager of the former General Petroleum Corp's Economics Department, has been named manager of the Programs and Analysis Section of Mobil Oil Co.'s Supply and Distribution Department. His office will be in New York. A graduate of Oregon State College, Kirk joined General Petroleum in 1929 as a clerk in the Comptroller's Department.

— *Deaths* —

William O. Barnes, 59, Eastern Division employe relations manager, Tidewater Oil Co., died January 6 at University Hospital, New York. Born in Logan, Utah, he served with the Army in World War I and in Peking, China, with the Marines from 1920-23. He joined Tidewater in 1925 as a laborer at the company's Avon, Calif., refinery and was named personnel manager there in 1936. He was placed in charge of eastern employe relations activities in 1955.

Rees F. Tener, 63, assistant chief of the Testing and Specifications Section, National Bureau of Standards, Washington, D.C., died December 25. A chemistry graduate of Marietta College and George Washington University, he joined the NBS staff in 1924 and served in the Rubber Section until 1930—then in the Testing and Specifications Section until his death. He was a member of ACS, ASTM, Washington Academy of Sciences, and Washington Rubber Group.

For more data on advertised products, use Readers' Service Cards, last page.

Photographed at Shell Oil Company (Houston, Texas, Refinery)

Cyanamid met a need... and produced the first successful 25% alumina catalyst

A few years ago, cooperation between a major refiner and Cyanamid went far beyond meeting the demand for continuously superior fuels. It developed a milestone in catalyst chemistry—fluid cracking catalyst AEROCAT TRIPLE A*, the first commercially successful 25% alumina catalyst.

AEROCAT TRIPLE A combines unusually high activity and stability for premium cracking efficiency. These properties provide high equilibrium activity and contribute to increased conversion at lower temperatures or reduced catalyst usage at severity levels required for low alumina catalysts.

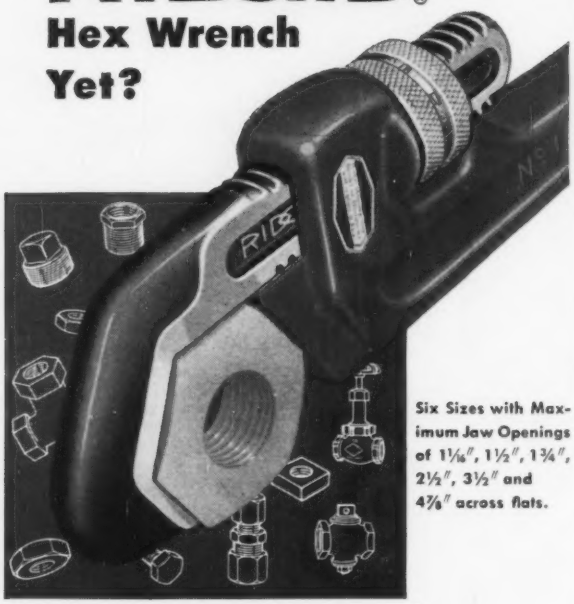
Cooperating with refiners is the most important part of Cyanamid's service. The skill and experience of your Cyanamid salesman—the Man with the Golden Rule—are supported by the resources of a major catalyst producer that is also a major manufacturer of other chemicals. Call your Cyanamid representative whenever you need his cooperation.

Basic in catalyst chemistry

CYANAMID

AMERICAN CYANAMID COMPANY • REFINERY CHEMICALS DEPARTMENT • 30 Rockefeller Plaza, N. Y., 20. N. Y.

Have You Tried a RIDGID® Hex Wrench Yet?



Six Sizes with Maximum Jaw Openings of 1 1/16", 1 1/2", 1 3/4", 2 1/2", 3 1/2" and 4 7/8" across flats.

the Perfect Mate for your RIDGID Pipe Wrench!

Finest of All Adjustable Smooth-Jaw Wrenches

MORE GRIPPING POWER... for all nuts. Puts a wrap-around grip on hexes that just won't slip. Because you're pulling with at least three flat sides at once, you'll never round off shoulders. Works on square nuts, valve packing nuts, unions and gas cocks and flat shapes, too. Smooth jaws won't even mar polished or plated surfaces.

RIDGID No. E-110 Offset Hex Wrench

Big Jaw, Short Handle for Sink and Tub Drain Nuts

Maximum Jaw Opening—2 5/8" across flats.

RUGGED CONSTRUCTION... built good and solid. Thin but extra-strong jaws slip into tight places. The first time you use a hex wrench you'll know that here's a wrench you'll use for a long, long time. It's every bit as rugged as your familiar RIDGID Pipe Wrench.

RIDGID No. E-11 End Hex Wrench

Offset Jaw for Easy Work in Tight Places

Maximum Jaw Opening—1 1/2" across flats.

From experience you know it's easier to work with the best of tools. Order your RIDGID Hex Wrenches from your Supply House today!

RIDGID®

The Ridge Tool Company • Elyria, Ohio, U.S.A.

over multiple source buying of YOUR laboratory needs

Make Curtin your one reliable source for laboratory supplies. Complete stocks of quality laboratory equipment are maintained for immediate delivery at supply points strategically located in all major refining areas. Technical and Repair Services are readily available all the time to help with your specific problems. Call Curtin on your next laboratory order and get "everything at one source."

W. H. CURTIN & CO.

DOMESTIC EXPORT • CURTIN PETROLEUM TESTING EQUIPMENT

HOUSTON - DALLAS - NEW ORLEANS - JACKSONVILLE

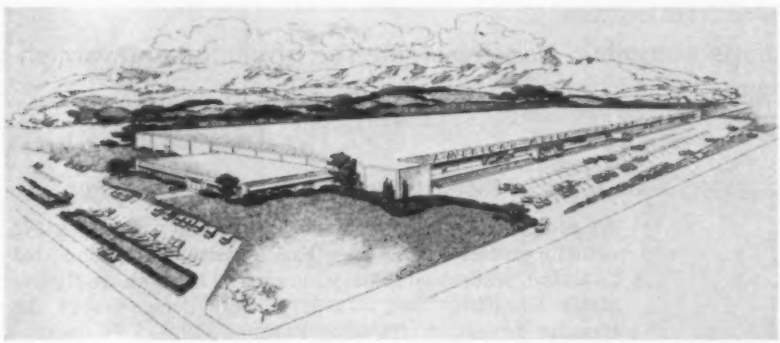
Sales Offices: TULSA • BIRMINGHAM • CORPUS CHRISTI

Subsidiary: CURTIN DE MEXICO, S.A. de C.V., MEXICO CITY

Established 1922 U.S.A.

Suppliers Notes...

J. A. McBride (left), president of Buell Engineering Co., Inc., and L. A. Eiben smile after signing agreements whereby Buell acquired Eiben's 49-year-old Northern Blower Co. Under terms of the acquisition, Eiben will continue to operate Northern Blower as a division of Buell.



A new 65,000 square foot addition has more than doubled the size of American Meter Co.'s Fullerton, Calif., plant. The new addition was constructed to house production, research, warehousing and customer service facilities for the company's Reliance Regulator Division, formerly located at Alhambra, Calif. The Fullerton plant was first opened in 1956.

BECKMAN INSTRUMENTS, INC. has named **John Bergman** corporate public relations representative, Fullerton, Calif. He had previously been a general assignment reporter for the Hollywood, Calif., *Citizen-News*. Bergman spent two years with the Los Angeles Bureau of International News Service and, earlier, was news bureau manager of Western Air Lines, and city editor of the Alhambra, Calif., *Post Advocate*.

SOCIETE EXPLOITATION DE PRODUITS INDUSTRIELS, Paris, has been licensed to manufacture and sell Selas Corp. of America's heat processing equipment throughout France. The French firm has been active as a Selas licensee for the past two years in manufacturing and selling gradiation heaters, and hydrocarbon and processing equipment to the petroleum, petrochemical and chemical industries in France.

SELAS CORP. OF AMERICA's Export Division has named **Paul J. Jaye** application engineer, Dresher, Pa. He joined Selas eight years ago, as machine designer in the Automatic Machinery Division. He later became application engineer in the Furnace and Kiln Division. Before joining Selas, Jaye was with the Brown Instrument Division, Minneapolis-Honeywell Regulator Co., and Quaker City Gear Works.

THOMPSON RAMO WOOLDRIDGE, INC. has named **Charles W. Chase** product planning manager, electronics, Tapco Group. He returns to Cleveland from the group's Southern sales region where he has been an electronics sales engineer. Chase joined TRW in 1956 after selling his electrical construction business in Sharon Center, Ohio. He received a B.S. degree in electrical engineering from Penn State University in 1943.

CONSOLIDATED SYSTEMS CORP. has elected **John J. McDonald** and **Linden G. Criddle** vice presidents. McDonald will continue as director of engineering and Criddle as director of operations. McDonald was appointed director of engineering when CSC became a subsidiary of Consolidated Electrodynamics last March. Previously, he was assistant director of the Systems Division for three years and manager of CEC's central regional office in Chicago for five years. Criddle joined CEC in 1954 as a systems engineer. He became manager of the Special Products Division in March 1956; assistant director of the Systems Division in December 1956; and director of operations for consolidated systems when the Systems Division became a CEC subsidiary.

THE ENJAY COMPANY, INC. has named **Gordon C. Seeler** marketing coordinator of its Paramins Division. He previously spent more than ten years with Esso Standard Oil Co., where he headed the Process Engineering Division, Bayonne Refinery. A graduate of the University of Minnesota with degrees in chemical engineering and business administration, he joined the former Standard Oil Development Co. in 1948 as a student engineer. He transferred to Esso's Bayonne plant in 1949. There, he was an engineer, coordinator, unit foreman for the Oil Movement & Storage Division, head of the Fuel Products Terminalling Division, and head of process engineering in 1958.

U.S. STEEL CORP.'s National Tube Division has named **Louis W. Mason** general manager of sales. He joined National Tube in 1923, and became assistant purchasing agent in 1930. In 1942, he was appointed manager of purchases, Tubular Alloy Steel Corp., Gary, Ind., a National Tube subsidiary. In 1944, Mason became assistant to the general manager of sales in National Tube's Washington, D.C., offices. Two years later he became district manager of sales, Detroit, and in 1946 was transferred to Pittsburgh in the same capacity. He was appointed assistant to the division's general manager of sales, Pittsburgh, in 1948, then moved to Chicago in 1950 as Central Area sales manager. He stayed in Chicago nearly nine years before moving to New York last year as Eastern Area sales manager.

WAGNER ELECTRIC CORP. has promoted **Harold N. Felton** from vice president of sales to vice president of marketing, and a director of the company. He will be responsible for the overall marketing activities of both the Electrical and Automotive Divisions. **Carl E. Widell,** director of market expansion, has been named assistant vice president, marketing. Mr. Widell will work with Mr. Felton in planning and carrying out specific marketing programs. **Ralph W. Boeringer** has been promoted from industrial rela-

For more data on advertised products, use Readers' Service Cards, last page.

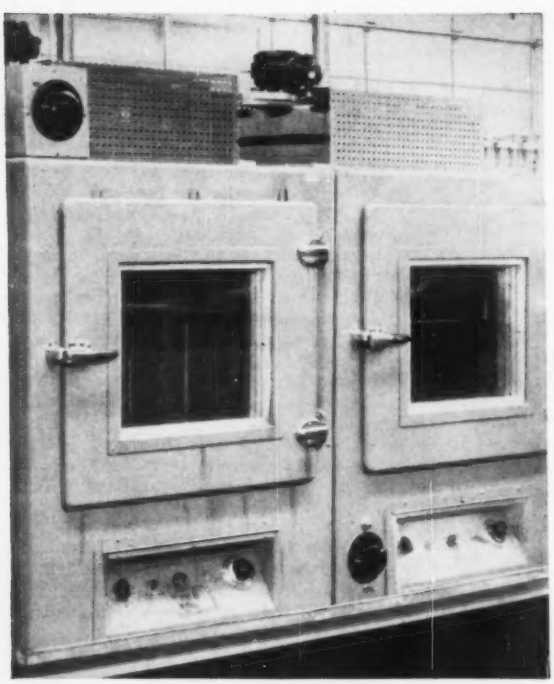
NEW PARANOX®

Detergent Inhibitor provides exceptional Oxidation Stability for Automatic Transmission Fluids

● FIGHTS SLUDGE AND VARNISH ● RESISTS DETERIORATION OF CLUTCH LININGS ● OILS BLENDED WITH PARANOX 375 EASILY MEET TYPE A, SUFFIX A REQUIREMENTS

Now, this newest of Enjay Prescription-Balanced Paramins® makes possible truly long-term oxidation stability.

In fact, Paranox 375 keeps automatic transmissions free of sludge and varnish after 35,000 grueling miles.



Decisive tests prove Clutch Plate Protection

In addition to providing oxidation stability, **Paranox 375** actually protects composition clutch plates. Tests conducted by an independent laboratory . . . such as the 50-hour Hydromatic Durability test . . . graphically demonstrated the superior protection offered by Paranox 375.

Oils containing Paranox 375 were still performing well after 6,300 cycles, in a durability test performed by an automobile manufacturer. Yet typical Type A, Suffix A fluids generally fail in this test before 1,000 cycles.

Prescription-balanced to control Rubber Swell Properties

As an extra safeguard, Enjay has developed the means of balancing base-oil stocks to meet rubber swell requirements. This service is available to you on Paranox 375 . . . or other ATFs developed through Enjay. In addition, new formulations are stringently tested by Enjay to assure their meeting all Type A, Suffix A requirements. For example, the Bench Oxidation Test . . . developed and used exclusively by Enjay . . . supplements Powerglide oxidation tests and other recognized standards.

EXCITING NEW PRODUCTS

ENJAY COMPANY, INC. *15 West 51st St., New York 19, N.Y.*

375

Filter Papers Show Paranox 375 Superiority

Good Reference Fluid

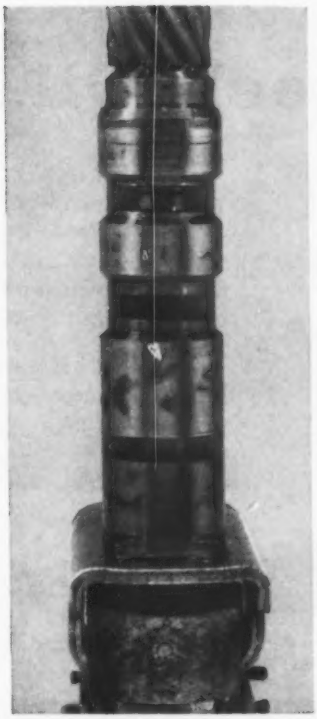
Hours	Demerits
81	(0)
121	(0)
142	(0)
168	(0)
192	(0)
200	(7)

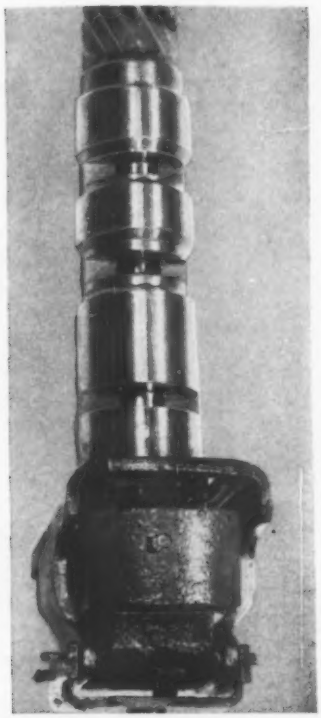
Samples filtered are from actual Powerglide tests with air injection.

Sludge on paper after filtering of fluid samples warns when oxidation resistance is lost.

Paranox 375 Fluid

Hours	Demerits
161	0
189	0
230	0
247	0
270	0
300	0





Tell-tale deposits begin at fluid "break point"

Shown here . . . Governors from two Powerglide transmissions . . . one on left with good reference oil . . . one on right with Paranox 375 formulation. Both oxidation tests made with air injection for 300 hours. The pictures tell the story.

	Viscosity (Centistokes)		
	100°F	210°F	V.I.
Base Oil A	18.7	3.71	89
Base Oil A+6.0 Vol.% Paranox 375	21.7	4.12	99
Base Oil B	16.4	3.37	77
Base Oil B+6.0 Vol.% Paranox 375	19.2	3.78	91

A Special VI boost... Another Paranox 375 Advantage

Paranox 375 has also shown the special quality of enhancing Viscosity Index of formulations, thus reducing VI improver treating costs. Shown here are two typical examples of what Paranox 375 does to improve VI of base oils.

Call upon Enjay for prescription-balanced additives that

. . . meet your exacting specifications
. . . help you market your products successfully

Enjay serves you

● with a *complete* line of petrochemicals to improve fuels and lubes ● with a larger staff devoted exclusively to additives research and manufacture . . . a staff available to help you meet your special additives requirements ● with quality controls at every production step to assure that each order meets specifications ● with expedited deliveries from Enjay product centers across the country.

For more information on how Paranox 375 and other Prescription-Balanced Paramins can improve your product's performance . . . and lower your treating costs . . . write or phone today.

THROUGH PETRO-CHEMISTRY

Akron · Boston · Charlotte · Chicago · Detroit · Los Angeles · New Orleans · Tulsa

ENJAY
ADDITIVES

For more data on advertised products, use Readers' Service Cards, last page.

BLUEPRINT FOR PROFITS

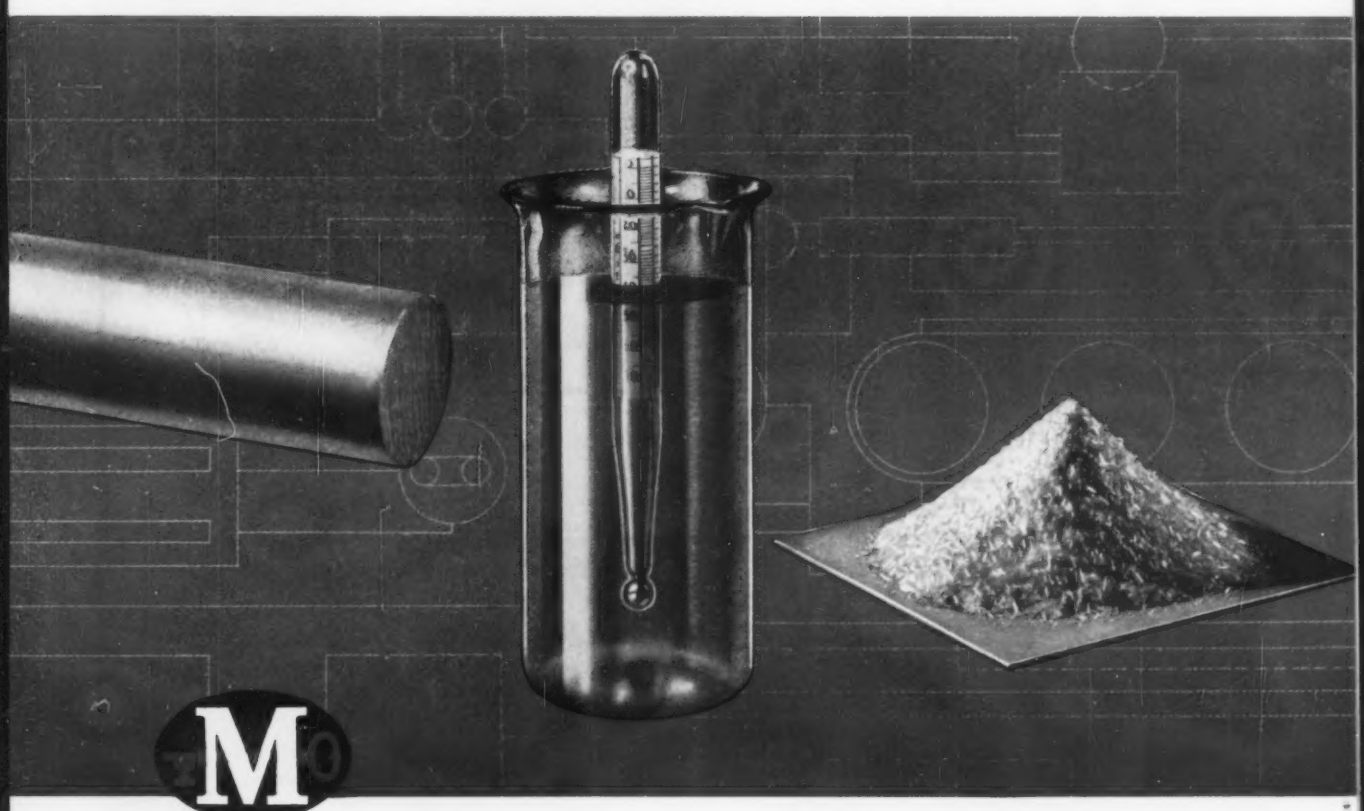
from Steel...Oil...Chemicals

IN steel, petroleum and chemicals, profits begin with plant design. A profitable plant must be designed and built to operate efficiently now and for many years ahead—must have the built-in flexibility to meet future conditions. It must produce at rock-bottom operating cost and require minimum maintenance.

If that is the kind of plant you need call in McKee. You'll find McKee engineers get things done—done right and on time. That's the result of many years of world-wide experience on projects like yours. McKee will convert your plant *cost* into profit-earning *investment* at the earliest date—give your profit column a head start.

McKee Building, Cleveland Headquarters

ARTHUR G. McKEE & COMPANY
2300 Chester Avenue • Cleveland 1, Ohio



OFFICES IN: CLEVELAND
NEW YORK • WASHINGTON
UNION, N.J. • HOUSTON, TEX.
TORONTO: ARTHUR G. McKEE & COMPANY OF CANADA, LTD.
ENGLAND: McKEE HEAD WRIGHTSON LTD. (PETROLEUM & CHEMICAL PLANTS OVERSEAS)
HEAD, WRIGHTSON & COMPANY, LTD. (BRITISH REPRESENTATIVES OF THE McKEE METALS DIVISION.)

McKEE ENGINEERING
AND CONSTRUCTION SERVICES

Suppliers . . .

tions director to vice president, industrial relations. Mr. Boeringer will continue to direct all operations dealing with the personnel of the company. **Harold S. Garrett** was promoted from assistant director of purchases to director of purchases.

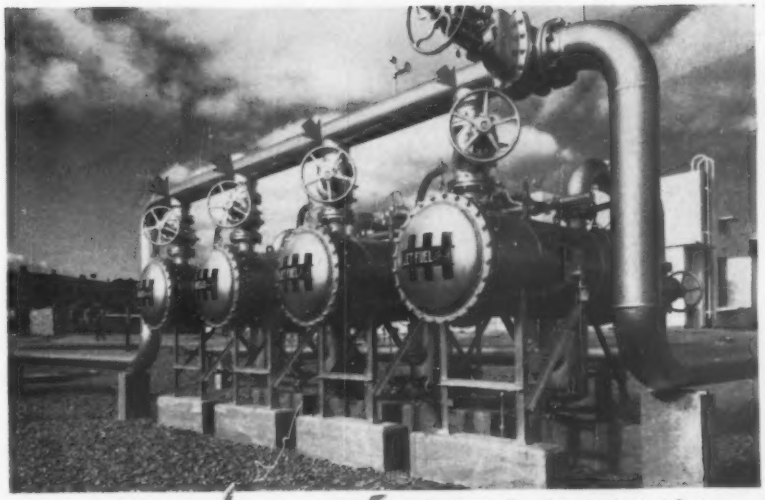
GENERAL CONTROLS CO. has named **Wilburn K. Robinson** regional representative in the Industrial Controls Division's Kansas City area. He will be in charge of sales and service of the company's line of industrial valves, counters, draft controls, valves and flow tubes. Robinson was formerly a sales engineer with Minneapolis-Honeywell Regulator Co., Kansas City. He was also an administrative assistant in the Aircraft Division, Ford Motor Co., Claycomo, Mo.

BECKMAN INSTRUMENTS, INC.'s Spinco Division has appointed **Walter E. Gordon,** formerly operations analysis manager for the Ford Motor Co. of Canada Ltd., controller. He will also be controller of the company's subsidiary, Shockley Transistor Corp. Both units are headquartered in Palo Alto, Calif. Gordon joins the Beckman organization after ten years with Ford in Windsor, Ont., where his positions included controllership and budgetary responsibilities, plus financial analysis.

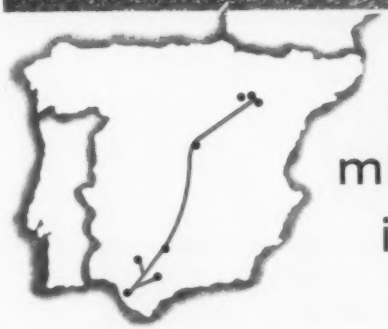
AMERICAN AIR FILTER CO., INC. has named **Russell C. Taylor** Pacific regional manager, San Francisco. **Charles J. Bressoud** has been appointed manager, Los Angeles branch office, succeeding Taylor. Taylor succeeds Vice President **Richard H. Nelson,** who has relinquished his responsibilities as regional manager but will continue as a company director. He has been with the Pacific Region since 1951, and has been in the Los Angeles branch office since 1952. Bressoud joined the Los Angeles office in 1954 as a sales engineer.

CRANE CO. plans to acquire The Swartwout Co., Cleveland. Terms of the transaction have not been disclosed. Immediate plans call for Swartwout to be operated as a division of Crane, without any basic changes in marketing policy. Crane has also acquired the operating assets of National-U. S. Radiator Corp. for cash. National-U. S. received from Crane more than $15 million in cash for plants, equipment and inventory. National-U. S. retained its accounts receivable, investments and cash.

PANELLIT, INC. has opened a Southwest Region office in Houston to provide more direct service to customers in Louisiana and East Texas. This office will handle sales and service on the company's line of process control equipment, including engineering, design, and fabrication of standard and graphic panelboards, annunciator systems, and related products and services. **Joseph E. Klueger** has been named sales manager, and **George H. Nolte** chief engineer for the Southwest Region. Klueger, who has been with Panellit since 1952, was assistant chief



Markowitz Bros. Inc., Mechanical Contractors
Miami, Florida



on the military pipeline in spain...

WELDOLETS were used for all branch connections on pumping station piping

Reinforced branch connections constructed with Weldolet Welding Fittings provide assurance of quality workmanship at the critical branch connection.

Savings in purchase price and construction on this project alone were high in the six figures. Piping designers and contractors who are interested in similar savings on their jobs are invited to write us for the Bonney Spanish Pipeline Brochure.

BONNEY

WELDOLETS®
THREDOLETS®
SOCKOLETS®
ELBOLETS®
BRAZOLETS®
SWEEPOLETS®

CARBON STEEL
STAINLESS
ALLOY
for all services

BONNEY FORGE and TOOL WORKS
ALLENTOWN, PENNSYLVANIA

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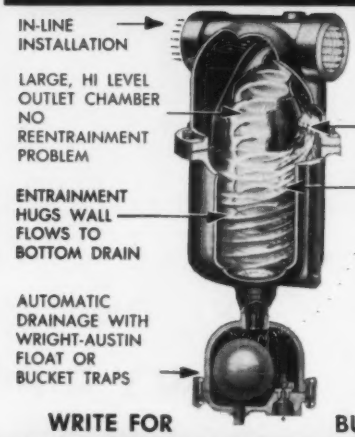
NEW T TYPE SEPARATOR

IMPROVED CYCLONE DESIGN

ASSURES MAXIMUM ENTRAINMENT SEPARATION


IN-LINE INSTALLATION
SCREWED OR FLANGED ENDS
LARGE, HI LEVEL OUTLET CHAMBER NO REENTRAINMENT PROBLEM
HI SPEED ENTRY— MAX. CENTRIFUGAL ACTION
CLEAN DESIGN PRODUCES MIN. PRESSURE LOSS
ENTRAINMENT HUGS WALL FLOWS TO BOTTOM DRAIN
AVAILABLE IN SIZES TO 8" PRESSURES TO 1,000 P.S.I.
AUTOMATIC DRAINAGE WITH WRIGHT-AUSTIN FLOAT OR BUCKET TRAPS
AVAILABLE IN SEMI OR CARBON STEEL

WRITE FOR BULLETIN 810-A

WRIGHT-AUSTIN COMPANY

3245 WIGHT STREET • DETROIT 7, MICH.

Suppliers . . .

engineer for the company and during the past year has been active in sales supervision throughout the Southwest area. Nolte has ten years' experience in engineering, manufacturing, and sales and was manager of panel manufacturing for the company before his transfer to Houston.

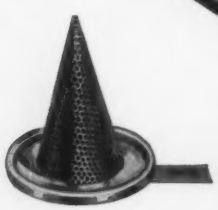
H. K. PORTER COMPANY, INC. has purchased more than 90 percent of the stock of The Patterson-Sargent Co., Cleveland. Patterson-Sargent has plants at Cleveland and Long Island City, N.Y. The company, which will operate as an H. K. Porter subsidiary, has made no changes in its organization.

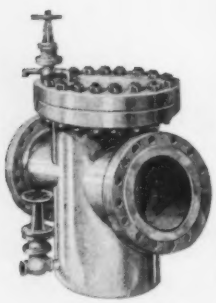
GENERAL CONTROLS CO. has named **R. Porter Fay** an Industrial Controls Division field representative in the Los Angeles sales office, Glendale, Calif. He was previously with Energy Control Inc., Philadelphia, as a sales and applications engineer.

BECKMAN INSTRUMENTS, INC. has appointed **Dr. James C. Sternberg** a senior research chemist with the Research Department, Scientific and Process Instruments Division. He received a B.S. degree in chemistry from UCLA, and M.A. and Ph.D. degrees from Harvard University. He has previous experience as a chemist with the U.S. Bureau of Mines, and as an assistant professor with the

MASTER PRODUCTS and CATALOG!

All MAC-IRON stock items, complete with detailed specifications, are listed on pages 653 through 660 of the newly released 1960 Refinery Catalog for your immediate reference.





MAC-IRON CATALOG A-9

Although you'll find our full line Catalog A-9 in the 1960 REFINERY CATALOG wouldn't you like more copies for distribution among your important engineering personnel?

Your request will bring all the copies you need. WRITE TODAY . . .

THE MACK IRON WORKS COMPANY

121 Warren Street

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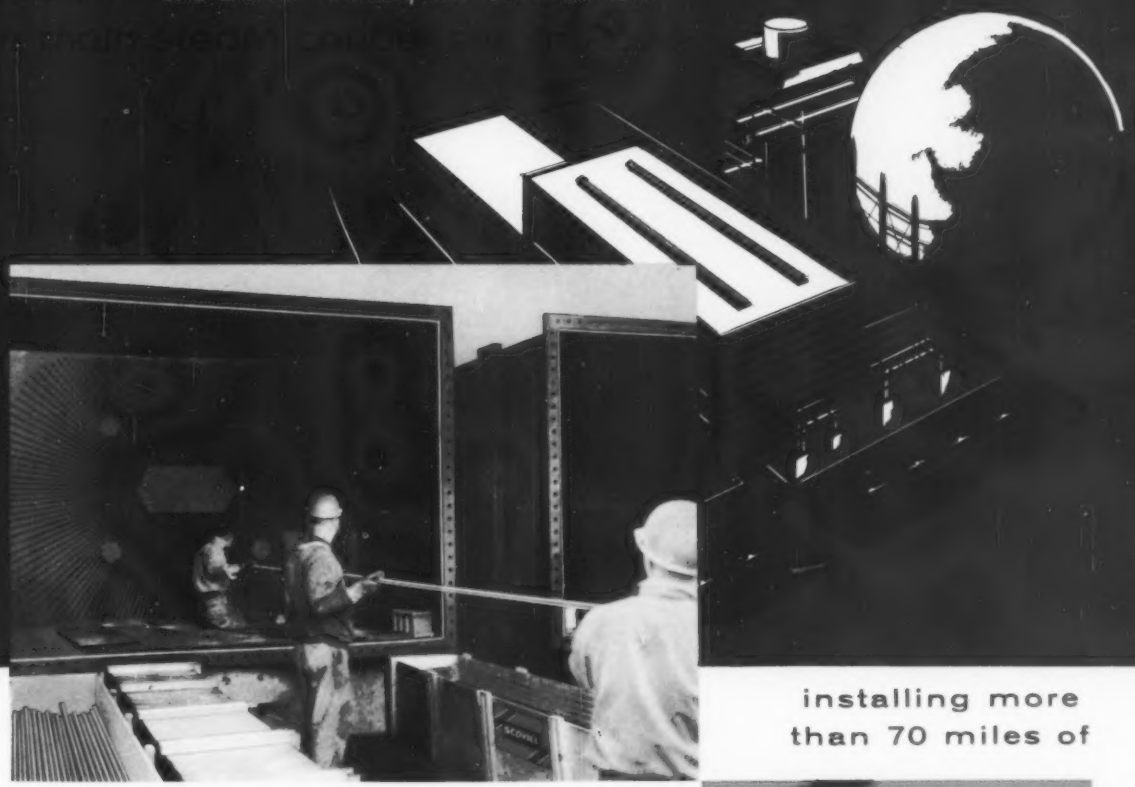
SPECIALISTS TO PETRO-CHEM-REFINING AND CHEM-PROCESS INDUSTRIES SINCE 1901

Stock and custom made items for many engineered applications which involve pumping of fluid materials and operational liquids.

BLINDS • SPACER RINGS • STRAINERS • PIVOT FLANGES

YANKEE ATOMIC

trouble-free performance



installing more than 70 miles of

SCOVILL®

INHIBITED ADMIRALTY

heat exchanger

TUBE

HEAT EXCHANGER TUBE for Applications from Marine to Petrochemical, from Compressor Intercoolers to "Cat-Cracker" Exchangers, in these popular Alloys . . . Phosphorized Admiralty • Admiralty • Arsenical Admiralty • Red Brass, 85% • Deoxidized Copper • Arsenical Copper • Cupro-Nickel, 10%-20%-30% • Aluminum Brass • Aluminum Bronze, 5% • Muntz Metal • Duplex Tube

HIGH RELIABILITY . . . trouble-free performance . . . has become a very specific goal of engineers in the Atomic Age.

This applies whether the problem is reliability of controls in a space vehicle or reliability of the operating equipment in New England's first Atomic Power Plant at Rowe, Massachusetts, being designed by Stone & Webster Engineering Corporation in collaboration with Westinghouse and constructed by Stone & Webster.

Scovill salutes the Yankee Atomic Electric Company's project, where 11 future-minded New England Utilities have set a new milestone in a field of unlimited promise.

Scovill's contribution is HEAT EXCHANGER TUBING . . . mile upon mile of precision-built tube that shoulders a major responsibility for the trouble-free operation of this installation.

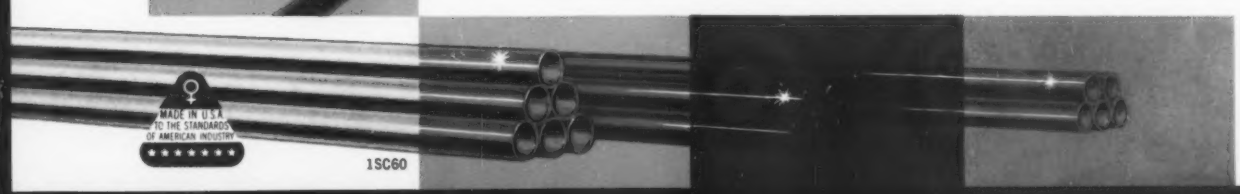
Here are shown being installed some of the more than 12,000, 30-ft. long Scovill Inhibited Admiralty Tubes (⅞" OD X .049" wall) specially made to extremely tight specifications for the main condenser in the Yankee Atomic Electric Company plant . . . over 70 miles of tube, every foot of which has passed the most rigid inspection.

Here, as elsewhere, Scovill Heat Exchanger Tube alloys and Scovill Technical Services have been recognized as among the finest available . . . to assure trouble-free performance.

SCOVILL

SCOVILL MANUFACTURING COMPANY

Mill Products Division, 99 Mill Street, Waterbury, Connecticut. Phone PLaza 4-1171.



1SC60

An Accurate, Time-Saving Way To Electrical Labor Estimating . . .

ESTIMATOR'S ELECTRICAL MANHOUR MANUAL

By John S. Page and Jim G. Nation

Price $10.00

Provides an accurate method of estimating direct labor for complete electrical installation in any given system or plant.

Before you think in terms of labor dollars for an estimate, there are many things to be considered. The most important of them being what is called productivity efficiency coupled with production elements.

The scores of manhour tables in this manual were compiled after detailed analysis of many time and method studies . . . covering all phases of electrical installations.

The manual points out how to arrive at a composite rate using productivity efficiency and production elements. With the composite rate, manhour estimating can be applied with equal validity to any electrical job, in any location.

The authors, estimators by profession, have found after much comparison on many projects, that production efficiency percentages can be classified into five categories: very low, low, average, very good and excellent. Production elements can be grouped into six different listings: general economy, project supervision, labor relations, job conditions, equipment, weather.

Using the above experience, the authors have devised an accurate and convenient method of estimating direct labor for complete electrical installation for any given system. Thus, by means of this Manual, the reader has a dependable method of obtaining a production efficiency percentage by applying all known local conditions and variables . . . plus a method of obtaining a complete direct labor rate for the craft or crafts involved in the various operations.

Subject areas covered include: Section 1—Conduit, Boxes and Fittings; Section 2—Service and Feeder Wiring; Section 3—Branch Circuit Items; Section 4—Lighting Fixtures; Section 5—Panelboards and Cabinets; Section 6—Safety Switches; Section 7—Hangers and Fasteners; Section 8—Underfloor and Buss Ducts; Section 9—Starters and Motors; Section 10—Mounting Transformers; Section 11—Outside Construction; Section 12—Underground Duct and Cable; Section 13—Communications and Signal Systems; Section 14—Demolition, Excavation and Concrete; Section 15—Technical Information.

Contains Scores Of Accurate Tables On

- Square boxes, covers and plastic rings
- Square gang flush device covers
- Suspended ceiling constructions
- Octagon boxes, round covers & plastic rings
- Outlet and gang wall condulets
- Miscellaneous condulets, elbows & bushings
- Gang floor box, handy or utility boxes
- Gang switch boxes and fittings
- Conduit—rigid galvanized & black enameled
- Flexible steel conduit
- Electric metallic tubing (thinwall)
- Cutting, reaming and threading conduit
- Shop and field fabricated conduit bends
- Standard types of bends
- Wire pulling, cable installation
- Solderless connectors
- Vertical riser cable supports
- Grounding material
- Switches & plates, receptacles & plates
- Surface metal raceway fittings, boxes
- Surface mounted multi-outlet assemblies
- Incandescent industrial fixtures
- Fluorescent and mercury vapor fixtures
- Reflectors, blank covers, end plates and couplings
- Lamp installation, outdoor floor lighting
- Standard panels and cabinets
- 250 and 600 volt panels and cabinets
- Auxiliary gutter or trough boxes
- 250 and 600 volt safety switches
- Deck cans and wall sleeves
- Split pipe rings, sockets & pipe riser clamps
- Beam clamps, expansion anchors, concrete inserts and ceiling flanges
- Miscellaneous fasteners
- Open bottom and closed bottom fiber ducts
- Underfloor steel ducts
- Branch circuit wiring for ducts
- Special raceways (ducts, elbows, tees, crosses, tap boxes, hangers, plug-ins, trolly duct)
- Motor starting switches
- Mounting and connecting dial type speed regulation rheostats
- Starting compressors
- 30 amp AC magnetic switches
- 3-pole 220 volt AC magnetic switches
- DC motor switches, motor rheostats
- Mounting motors
- Air cooled and oil cooled transformers
- Overhead street lighting
- Pole setting, pole anchors, guys
- Cross arms, pins & secondary racks
- Stringing wire, aerial cable, grounding
- Primary & secondary protective devices
- Pole mounted distribution line transformers
- Distribution line regulators & capacitors
- Miscellaneous overhead service items
- Fiber and clay duct installation
- Cement asbestos duct installation
- Lead covered and direct buried cable
- Cable splicing
- Apartment house telephones
- Burglar alarm and centralized radio systems
- Clock, program and fire alarm systems
- Hospital signaling systems
- Intercommunications, public address systems
- Miscellaneous signal system devices
- Raceway, cable and wire, power supply
- Channeling concrete, brick & tile construction
- Cutting holes in wall, excavation for poles
- Machine excavation for ducts and manholes
- Hand excavation for ducts and manholes
- Rock excavation for ducts & manholes
- Shoring and bracing trenches
- Disposal of excavated material
- Backfilling and tamping
- Duct encasement and manhole forms
- Duct encasement and manhole concrete

Order from:

Book Department

GULF PUBLISHING COMPANY

P. O. Box 2608, Houston 1, Texas

Or - From your local bookstore

For more data on advertised products, use Readers' Service Cards, last page.

Suppliers . . .

Department of Chemistry, Michigan State University. At Beckman, he will participate in physical-chemical and instrumentation research.

THE THOMPSON-RAMO-WOOLDRIDGE PRODUCTS CO. has established a sales engineering office in Houston. **Rigdon Currie,** Southwestern regional sales manager, heads the new office, located in the Niels Esperson Building. He is responsible for all sales activities in Texas, Oklahoma, Arkansas, Louisiana, and New Mexico. Currie received his B.S. degree in industrial engineering from Georgia Institute of Technology in 1951 and his M.B.A. degree from the Harvard Graduate School of Business Administration in 1956.

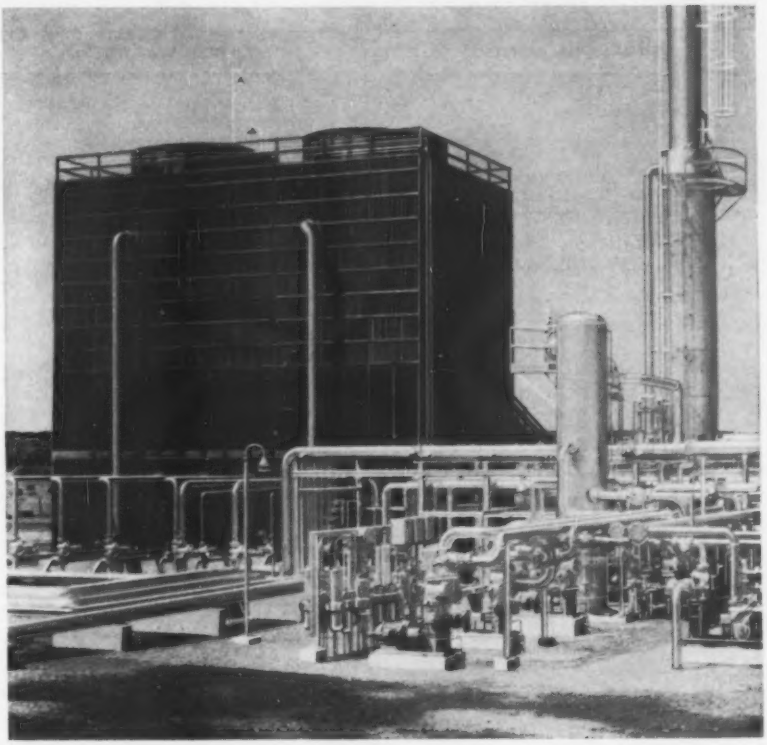
FOOD MACHINERY AND CHEMICAL CORP. has named **Robert A. Bondurant, Jr.,** manager of the Chlor-Alkali Division. He was previously resident manager of the division's soda ash facility near Green River, Wyo. After joining FMC in 1936, Bondurant served in production and process supervisory positions at the South Charleston, W. Va., chemical plant. He transferred to the New York office as plant representative in 1951, a position he held until becoming assistant to the division manager in 1955. He became special projects manager for the division in 1956.

CHEMSTRAND CORP. has elected **John L. Gillis** a member of the board. He is vice president of marketing, Monsanto Chemical Co., and a member of the company's board and Executive Committee. Gillis joined Monsanto in 1933 at St. Louis as assistant export manager and later became export manager and director of the former Foreign Department. He became a vice president in 1950, and general manager of the Organic Chemicals Division in 1951. He attained his present position in 1953, was elected a Monsanto director in 1955, and became a member of the Executive Committee in March, 1958.

BECKMAN INSTRUMENTS, INC. has appointed **Willard B. Gregory** public relations manager, Fullerton, Calif. He has been with Beckman since 1955, having served first as publicity writer and most recently as corporate public relations representative. Before joining Beckman, Gregory spent four years in the Los Angeles Bureau of United Press. Earlier he served as a reporter for the Santa Ana, Calif., *Register,* and the Las Vegas, Nev., *Review-Journal,* and as editor of the Anaheim, Calif., *Gazette.* He is a graduate of Pomona College.

ELECTRONIC ASSOCIATES, INC. has named **Dr. Lloyd G. Lewis** manager of the newly formed Process Control Group. Dr. Lewis' group will seek to apply the principles of analog computation with EAI's associated computing components to the control problems of the process industries. Particular attention will be given to the petrochemical field. Before joining EAI, Dr. Lewis had been with

WANT LOWER CORROSION CONTROL COSTS?



Research and experience with water problems in every kind of industry is why the Calgon Company can save you money by lowering corrosion rates and treatment costs. The service starts with a survey of the system, and includes water analysis, both at the source and in use, a review of flow rates, temperatures, equipment types and usage and other pertinent factors. This is followed by complete treatment recommendations and continuing service after treatment is started. Here is why Calgon methods can save you money and maintenance:

LOWER CHEMICAL COSTS: In most systems, treatment is substantially lower in cost. This is because of more effective treatment, which means that smaller amounts of chemicals can be used.

LOWER WATER COSTS: With more effective treatment, it is frequently possible to maintain higher solid concentrations in cooling water. This means less makeup water, and consequent savings in overall water costs.

BETTER RESULTS: In one typical plant, water treatment in use resulted in a corrosion rate of 4 mils per year. When Calgon methods took over, corrosion rates were reduced to 1 mil per year, troublesome deposits were also eliminated, and chemical costs came down at the same time.

A letter or phone call will put Calgon Engineers to work on your particular problem.

CALGON COMPANY
HAGAN BUILDING, PITTSBURGH 30, PA.

DIVISION OF **HAGAN** CHEMICALS & CONTROLS, INC.

For more data on advertised products, use Readers' Service Cards, last page.

SITUATIONS WANTED

■ Chemical Engineer, BSChE, four years natural gasoline plant and field work major company, seek challenging position with opportunity for advancement—prefer petrochemicals or refining. Age 28. Box 331R, PETROLEUM REFINER, Houston, Texas.

HELP WANTED

Chemist or Chemical Engineer

With Broad Knowledge of Refining Industry for technical writing and editing on refining industry motor fuel, lubricants, petrochemical and related fields. Prior writing or editing experience desirable. Creative, important job. Send resume to:

PERSONNEL DIRECTOR
ETHYL CORPORATION
1600 West Eight Mile Road
Ferndale 20, Michigan

SPECIAL PETROLEUM REPRESENTATIVE

Established manufacturer of industrial processing materials has opening for a special representative in the Great Lakes Region.

Applicants must be 25-40 years of age and must have petroleum refinery experience in the mechanical, engineering, processing, or operations department. 60% travel, salary, plus expenses.

This is an unusual opportunity for a capable man looking for permanency and above average earnings.

Reply giving full details of education, background and personal status to box number 332-R. PETROLEUM REFINER, Houston, Texas.

Chemical Engineer

Graduate Chemical Engineer with from two to four years petroleum refining experience in process design or operations.

Duties will be closely integrated with operation of a modern, independent refinery which includes crude distillation, catalytic cracking, polymerization, coking, hydrodesulfurization, catalytic reforming, alkylation, and utilities.

Send complete resume of education and experience, including salary requirements. All replies confidential.

GREAT NORTHERN OIL COMPANY
P. O. Box 3596
ST. PAUL 1, MINNESOTA
ATTN: C. L. Dretzke

Send for your FREE copy of the New Petroleum Books Catalog containing descriptions of many books pertaining to the Petroleum Industry. Send your request to Book Department, Gulf Publishing Co., P. O. Box 2608, Houston 1, Texas.

HELP WANTED

MARKETING EXECUTIVE FOR A MAJOR COMPANY LPG or PETROCHEMICAL

To function at management level in establishing new, sizeable LPG organization. Age 45. Position requires considerable experience in marketing, including short and long-term wholesale contract negotiations and administration. Must have experience in assessing market potentials and some experience in storage and transportation. Retail experience desirable. Salary commensurate with ability and experience. Send resume including background, training and experience. All replies will be held in strictest confidence.

Mr. G. E. Montes

NORTHERN NATURAL GAS COMPANY
2223 Dodge Street
Omaha, Nebraska

engineers

Major Company is developing an extensive diversification program calling for a wide variety of top-level talent as follows:

1. **Chemical or petroleum refining process design, project development and/or operation.**
2. **Air separation plant design and operation or related cryogenic experience.**
3. **Hydrocarbon extraction design or operation experience.**
4. **Engineering Economic evaluation.**

Prefer minimum of five years' experience appplicable to any one or combination of above.

Address replies with full resume in complete confidence to: Box 330-R. PETROLEUM REFINER, Houston, Texas.

FOR SALE

Specify SAUEREISEN
ACIDPROOF CEMENTS—COMPOUNDS FOR
Tanks, Sewers, Stacks, Floors
Technical coments for all purposes.
Send sketches or samples
Sauereisen Cements Company · Pittsburgh 15, Penna.

When you see a large chimney think of Sauereisen Cements.

Suppliers . . .

Standard Oil Co. (Indiana) as head of the Analog Computer Section. He was responsible for the design and development of several servo systems. Dr. Lewis received his B.S. degree in physics and Ph.D. degree in cosmic ray and nuclear physics from the University of Chicago. At Armour Research Foundation, Illinois Institute of Technology, he did work in hydraulics, ultra-sonics, high vacuum techniques and radiography and scanning.

AMCEL PROPULSION, INC. has named **Dr. Clayton M. Huggett** director of research. He was previously with Rohm & Haas Co. as head of the company's high pressure laboratory. Before that, he was resident director of research at Rohm & Haas' Redstone Arsenal Research Division. He holds a Ph.D. degree in physical chemistry from the University of Minnesota and is a former member of the U.S. Navy Bureau of Ordnance Advisory Committee on Solid Propellants.

FISCHER & PORTER & CO. has named **Donald T. Cusack** Eastern regional sales manager. He will be responsible for the New England, Eastern New York, and Northern New Jersey sales regions. Formerly district manager in the New York area, Cusack is a graduate of Stevens Institute of Technology and holds a M.S. degree in electrical engineering from New York University. He is a senior member of ISA.

HOOKER CHEMICAL CORP.'s Durez Plastics and Western Chemical divisions have relocated at 6277 East Slauson Ave., Los Angeles 2, Calif. These offices are to be consolidated with modern warehouse facilities for the company's products in the new warehouse of Interamerican Warehouse Corp. at this location, where all company stock for the area will be stored henceforth.

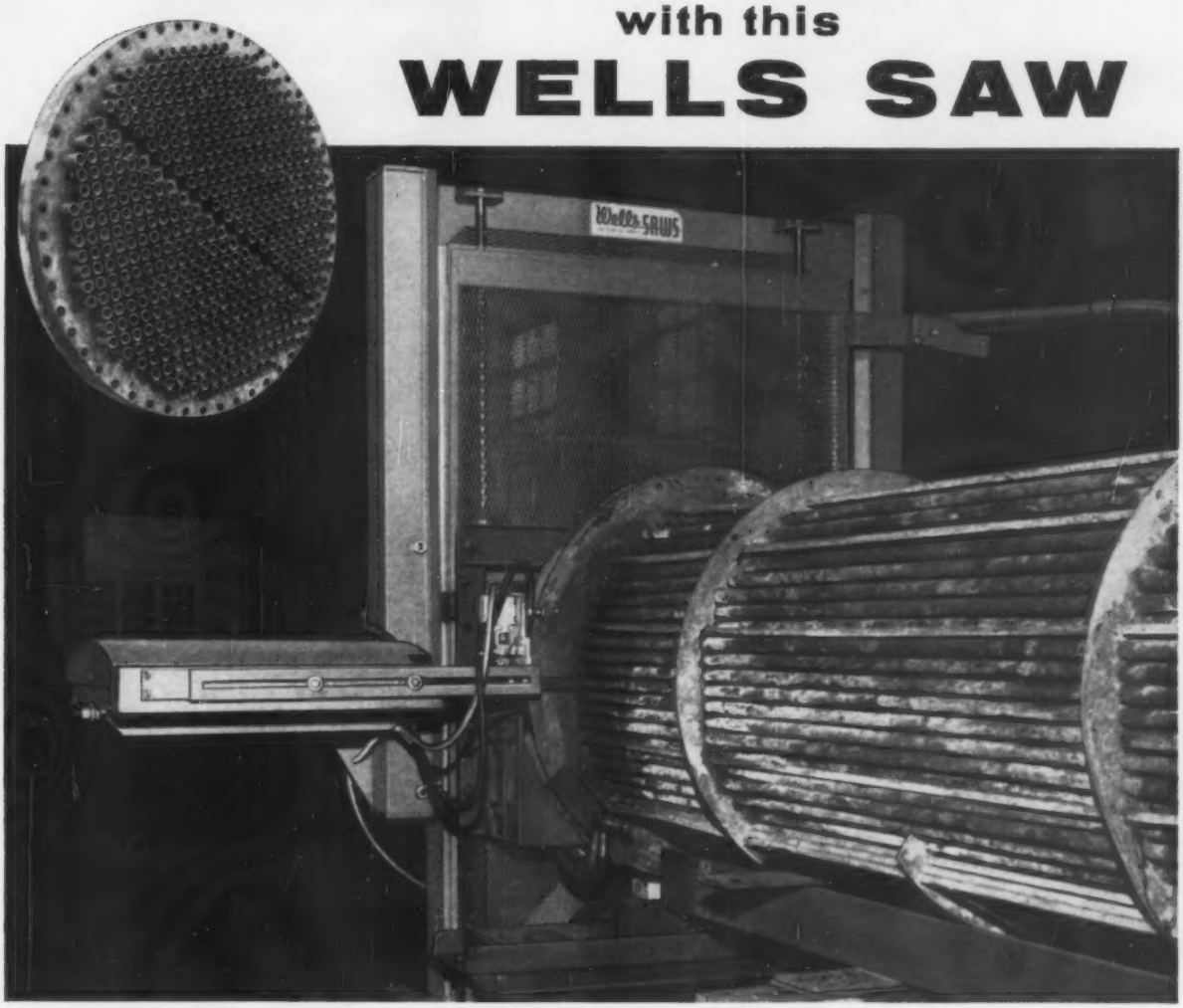
FOR SALE

NEW WATERLESS DECALS
Permanent type tough "Vinyl" applied in seconds without water, saves labor; no curling in storage. MADE TO YOUR SPECIFICATIONS...lettering, numbers, your trademark. Send now for FREE SAMPLES and estimate.
SCREEN PROCESS PRINTING CO., P.O. Box 848, Wichita 1, Kansas

REFINERY INSPECTION GAUGES
JOHN J. BECKER CO.
BRADFORD, PA.

BRODIE METERS
FOR SALE
For gasoline, Model B-62D, 3" $250.00
Also Rockwell Rotocycle meters.
H. L. BOGGESS & SONS, Liberty, Missouri

Cut Heat Exchanger Tube Bundles SAFELY . . . QUICKLY . . . CLEANLY . . . with this WELLS SAW



TYPICAL OPERATING DATA
(job illustrated above)

Type of Bundle	Debutanizer Condenser
Stationary Head	40½"
Sheet Floating Head	35-11/16"
Head Thickness	3¼"
Type of Material	Brass
Number of Tubes	480
Diameter of Tubes	1"
Gauge of Tubes	14
Type of Material	Copper Nickel
Size of Blades	21'0" x 1¼" x .042"
Teeth per Inch	8
Blade Speed	135 FPM
Cutting Time	165 Minutes

Write for Bulletin SM658 →

This is the Wells Model 12-20G-60 in action. Special Heavy-Duty Cut-Off Machines like this, developed by Wells Manufacturing Corporation, specifically for cutting tube bundles, are now doing the job efficiently in many oil refineries and chemical plants.

Model 12-20G makes safe and easy work of this difficult, hazardous, time consuming job, and materially reduces the cost of heat exchanger maintenance.

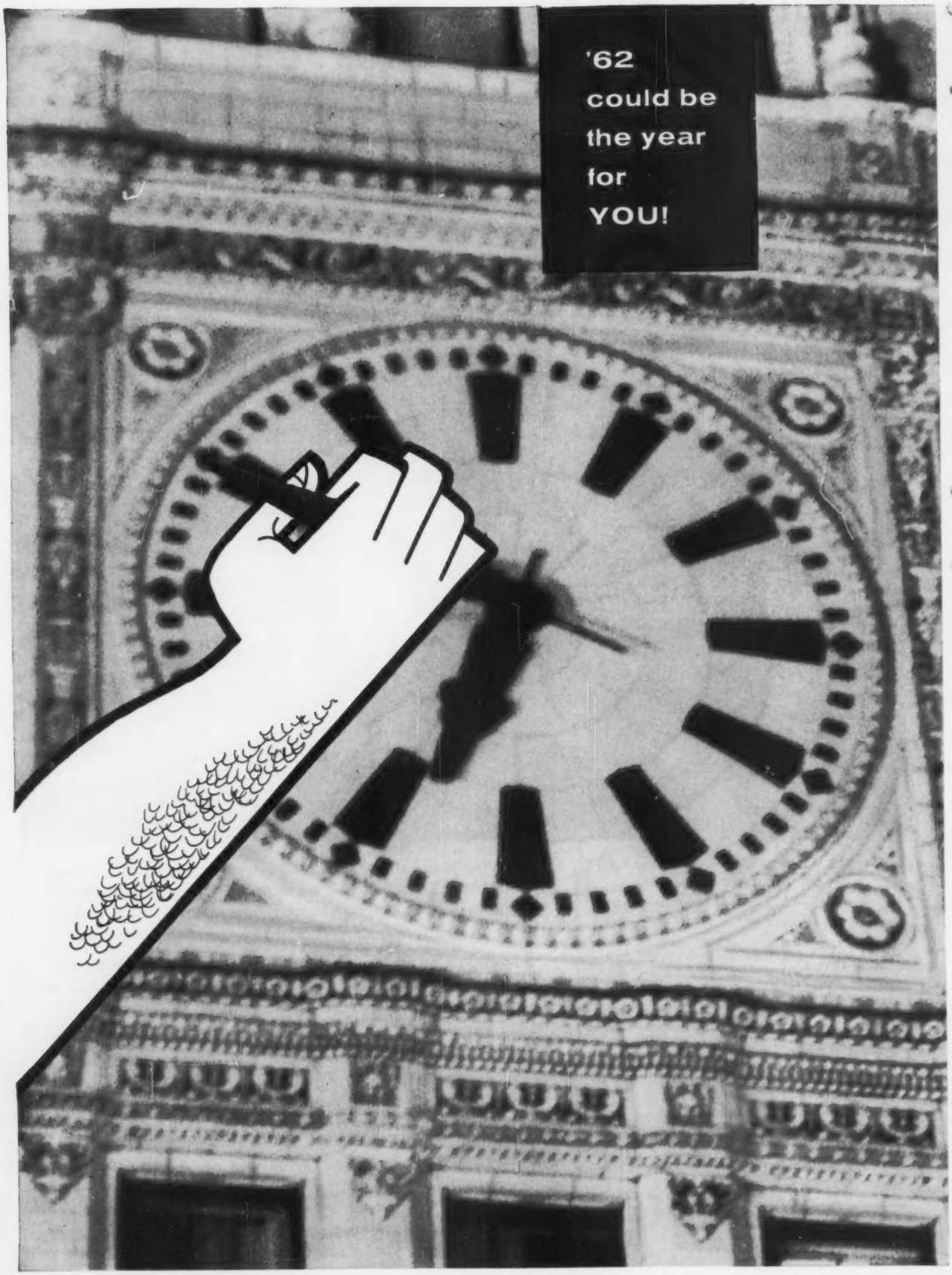
Standard models are available for cutting 48" or 60" diameter bundles. J.I.C. electrical standards and modifications of basic design are available to meet individual requirements.

If a safer, more practical, less costly method of cutting tube bundles is of interest to you, write for complete information.

Wells SAWS
Wells®

The Pioneers of Horizontal
METAL CUTTING BAND SAWS
WELLS MANUFACTURING CORPORATION
880 Service Road — Three Rivers, Mich.

For more data on advertised products, use Readers' Service Cards, last page.



For more data on advertised products, use Readers' Service Cards, last page.

you can't stop time!

Nor progress! They both march on . . . creating change and opportunity.

Right now, for example, the petroleum refining industry has adequate crude capacity, but is running short on certain intermediate and gasoline finishing processes. According to the consensus of informed opinion, present catalytic cracking, reforming, and alkylation capacity will be insufficient to meet anticipated demand in 1962.

In creating demand for more and better products, you can make time work in your favor. It can also work against you! It takes *time* to plan, build and put into operation new or expanded process facilities . . . in most cases from one to two years.

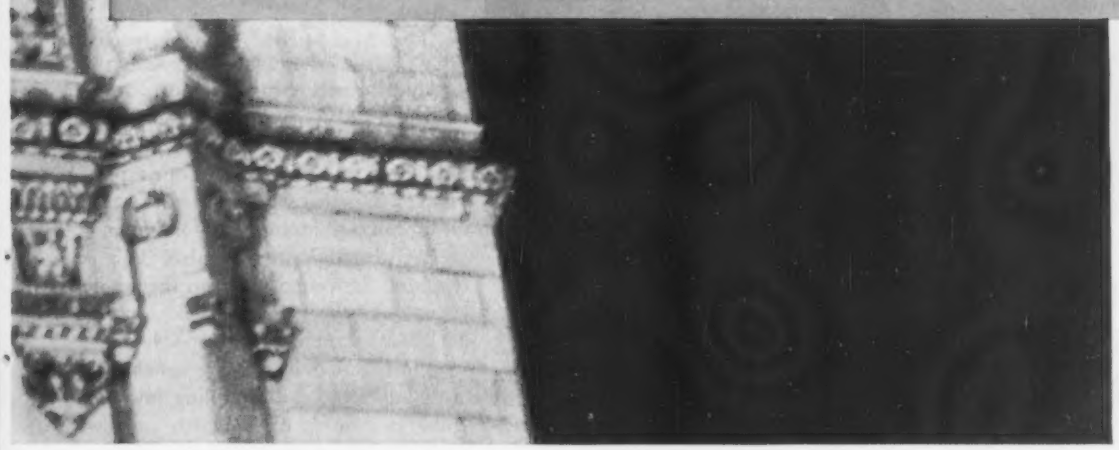
Be ready . . . plan now for '62!

UOP

UNIVERSAL OIL PRODUCTS COMPANY

30 ALGONQUIN ROAD, DES PLAINES, ILLINOIS, U.S.A.

WHERE RESEARCH TODAY MEANS PROGRESS TOMORROW



For more data on advertised products, use Readers' Service Cards, last page.

New Equipment & Literature...

Automatic Open-Cup Flash Test Developed

The Research Department of Socony Mobil Oil Co., Inc., has developed a new device that automatically performs the Cleveland Open Cup Flash Test.

The new automatic flash tester reduces by one-third the amount of working time required to perform a common test used in refineries and laboratories to assure that lubricants meet quality specifications.

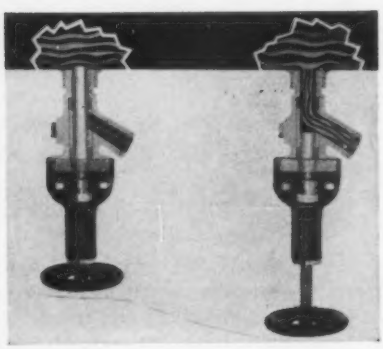
A license to manufacture the new flash tester has been awarded to Precision Scientific Co.

Circle E1 green card, last page

Fittings Cut Low-Pressure Piping Costs

A line of light-weight Pipe-Mate fittings and flanges has been expanded to include aluminum alloys and most other weldable metals and alloys. The complete line of Pipe-Mate fittings is available in ½ to 4-inch pipe sizes, Schedule 10S. Pictured are 2½ and 3-inch elbows, a 3 x 2½-inch concentric reducer and 3-inch stub end of Type 6063T6 high-strength aluminum alloy. Light weight contributes to lower shipping costs, easier handling and lower installed cost for nominal temperature, low-pressure process piping. The fittings feature long tangents permitting easy alignment of pipe and fittings, and fabrication of completely flanged elbows, returns, tees and crosses. A variety of installation methods includes butt welding; fillet welding or brazing with the use of an aligning connector; Victaulic coupling, use of a stub end and backup flange, and a unique "rolled-in" flange assembly. Tube Turns Div. of Chemetron Corp.

Circle E2 green card, last page



Sampling Valve Can't Clog And Delivers True Sample

A new sampling valve has been designed to produce samples without failure. No settlement or clogging can ever stop it from producing a live sample.

This new valve is so constructed that, when in a closed position the stainless steel piston extends to the inner surface of the vessel or pipe, to which it is connected. When this piston is retracted to the open position, a sample is guaranteed because it is impossible for any foreign material to gather in the valve. This is because the piston takes up the whole interior of the valve to itself.

These sampling valves are made for installation in existing systems by welding a ¾" half coupling into the pipe or vessel, from which samples

How B&W JOB-MATCHED TUBING saves in oil heater applications

... A complete range of carbon, alloy and stainless steels—permits choice of steel to match service conditions.

... A wide size range—provides for freedom of design.

... Uniform dimensions and mechanical properties — helps to provide ease of fabrication.

These are just a few of the reasons it pays to specify B&W Job-Matched Seamless Pressure Tubing. Call the tubing specialist at your local B&W District Sales Office, or write for Bulletin TB-417 for full information. The Babcock & Wilcox Company, Tubular Products Division, Beaver Falls, Pennsylvania.

B&W

THE BABCOCK & WILCOX COMPANY

TUBULAR PRODUCTS DIVISION

TA-9016-SP2

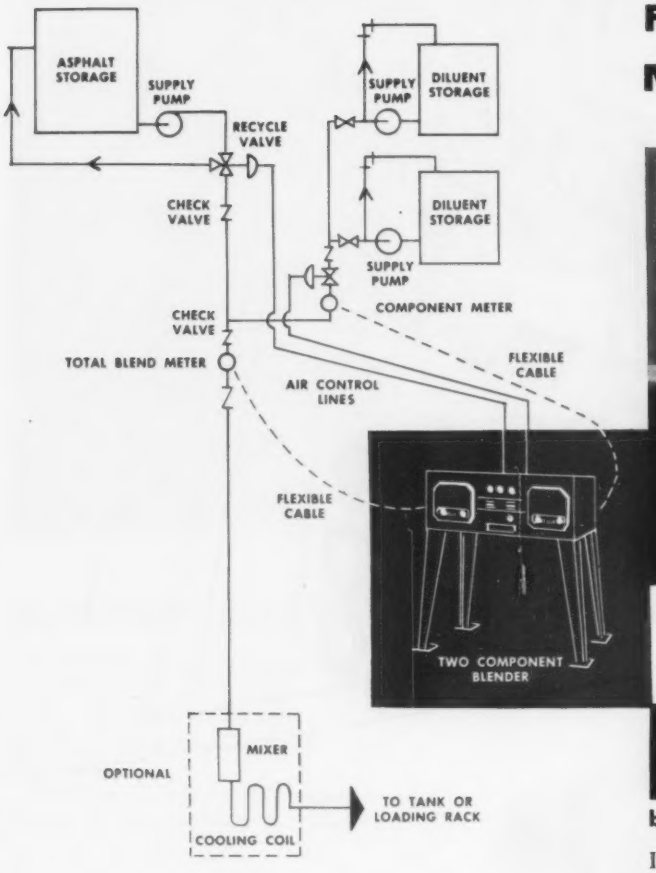
Seamless and welded tubular products, solid extrusions, seamless welding fittings and forged steel flanges—in carbon, alloy and stainless steels and special metals

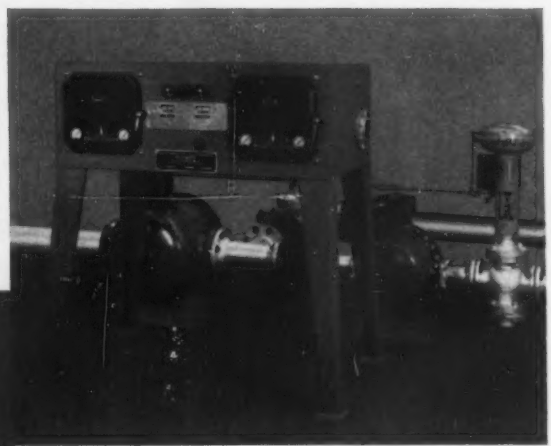
For more data on advertised products, use Readers' Service Cards, last page.

POSITIVE CONTROL OF MATERIALS IN MOTION B-I-F METERS FEEDERS CONTROLS

LOADING DOCK BLENDING OF ASPHALTS . . .

FASTER, SAFER, MORE PROFITABLE!





B-I-F Proportioneers **continuous, automatic in-line blenders streamline asphalt operations!**

In a single operation, loading dock personnel line up the proper asphalt and cutter stock . . . set and reproduce any required blend . . . load cutbacks, as a stable end product of predetermined viscosity, directly into mobile equipment. In addition, the Proportioneers system eliminates any fire hazard, loss of time and materials, and need for redoping and subsequent mixing. Efficient, economical stream blending is a more flexible, cleaner operation. Requires only a minimum inventory for maximum production.

Modifications include control of additive injection, ticket prints for proof of product, and interlocks identifying base stocks.

B-I-F Industries

BUILDERS-PROVIDENCE • PROPORTIONEERS • OMEGA

METERS • FEEDERS • CONTROLS / CONTINUOUS PROCESS ENGINEERING

For complete details on how to streamline your asphalt operation, request Bulletin SM-9477.

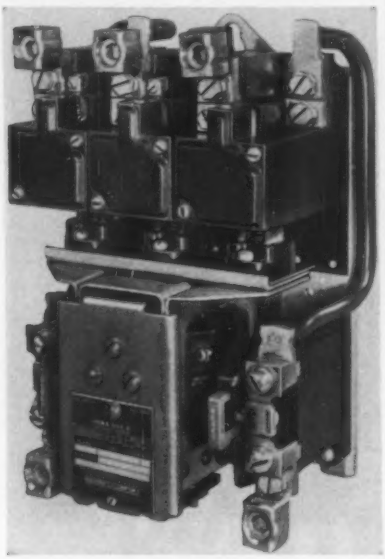
Write **B-I-F Industries, Inc.,**
412 Harris Avenue, Providence 1, R. I.

are required. They are made with the ¾" male pipe thread inlet and ½" female pipe thread discharge. Straham Valves.

Circle E3 green card, last page

NEMA Size 4 Motor Starter Is 33 Percent Smaller

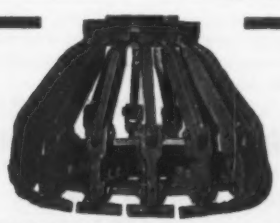
A compact new NEMA Size-4 starter which is 33 percent smaller has just been announced. The new starter retains the long-life electrical and mechanical characteristics of the previous design. Di-



mensions are 12⅜ inches by 8¼ inches by 6 5/32 inches.

The new starter features trip-free melting-alloy overload relays with unit-construction thermal units, or adjustable bimetallic overload relays with hand and automatic reset. Up to four double-circuit interlocks may be added.

Molded coils plus contact blocks



BARRETT automatic
Filling and Crimping Equipment
for handling greases and other viscous fluids.
- No operator required.
- 100% air operated.

Fills, seals, stamps and counts lug cover pails. Output of 15 pails per minute. Write for details on installation to meet your requirements.

BARRETT
Manufacturing Co.
P. O. Box 8096, Houston 4, Texas

from the makers of Dimetcote...

ZINKOTE

THE FIRST 100% INORGANIC *SELF-CURING* ZINC COATING...

- A radically new concept in zinc coatings for protecting steel.
- Under development for many years and first patented in 1957.
- Applied in one coat – completely self-curing.
- Can be used wherever galvanizing is satisfactory – actually gives superior protection.
- Completely nonflammable, nontoxic.
- Insoluble in all petroleum products.
- Outstanding resistance to weathering, salt and fresh water.
- Applied by brush, spray or roller.
- Cathodically protects steel.
- Resists temperatures up to 600°F.
- Complete protection for as little as 5¢ per square foot material cost.

How does Zinkote compare with Dimetcote?
Although similar, each has certain unique advantages depending upon the particular requirements of the job. We will be glad to give you a specific recommendation.

For complete information write . . .

Amercoat® CORPORATION

Dept. VB • 4809 Firestone Boulevard • South Gate, California

921 Pitner Avenue, Evanston, Illinois
360 Carnegie Avenue, Kenilworth, New Jersey
2404 Dennis Street, Jacksonville, Florida
6530 Supply Row, Houston, Texas

The Pioneer Manufacturer of Inorganic Zinc Coatings.

118A

easy way to keep tubular equipment good as new

Airetool tubular maintenance tools give work crews everything they need to clean boiler condenser and heat exchanger tubes faster, more efficiently. These tools are designed with plenty of power to get the job done right — in a hurry.

The lightweight Model CC-475 Airetool condenser and heat exchanger tube cleaner drives cleaning heads through hardest deposits without stalling . . . at the same time, a built-in flushing system washes out debris. Yet this hard-working tool weighs only 10 pounds — one man handles it easily without a supporting rig. And, when it comes to retubing bundles, Airetrol, automatic tube expansion control can't be beat. It easily rolls up to twelve ¼" to 1½" tubes per minute.

For cleaning large diameter curved tubes Airetool air-driven cleaner head motors produce high speeds and extra power for heavy duty performance. Motors maintain speed and power even when the most severe deposits are encountered.

For complete information about these time and money-saving Airetool tube maintenance tools that keep condenser and heat exchanger tubes operating at like-new efficiency, write for Bulletin No. 66.

30 years experience in pneumatic tools

BRANCH OFFICES: New York, Chicago, Tulsa, Philadelphia, Houston, Baton Rouge
REPRESENTATIVES in principal cities of U.S.A., Canada, Mexico, South America, England, Europe, Puerto Rico, Italy, Japan, Hawaii
CANADIAN PLANT: 37 Spalding Drive, Brantford, Ontario
EUROPEAN PLANT: Vlaardingen, The Netherlands

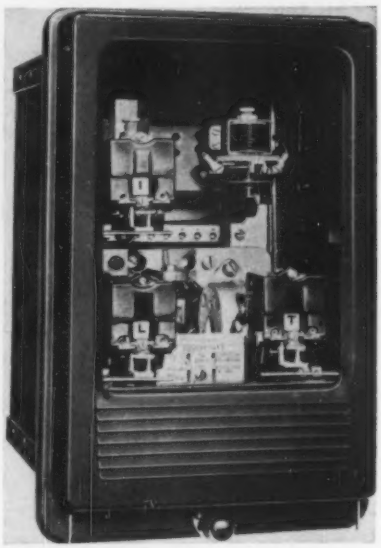
AIRETOOL
MANUFACTURING COMPANY
SPRINGFIELD, OHIO

Equipment . . .

molded of inorganic, non-carbon tracking material provide extra electrical life. Large contact tips of special silver alloy also contribute to long life as well as easy inspection and maintenance. Square D Co. **Circle E4 green card, last page**

Relay Protects Motors From Light to Heavy Overloads

A new relay for complete motor protection from very light to heavy overloads is available. The relay provides protection by combining several elements



to more closely match the motor heating curve.

From minimum pickup to 175 percent of tap-value setting, an alarm is sounded and an operator is allowed five to ten minutes to remove the trouble. With medium overloads, the COM-5 gives normal time-delay tripping protection. The relay provides for instantaneous tripping on heavy-fault current.

In the past, a number of independent relay packages were required for complete motor protection. Now, with the new relay, a more convenient and versatile package is provided. Westinghouse Electric Corp.

Circle E5 green card, last page

REFRACTORY HAYDITE

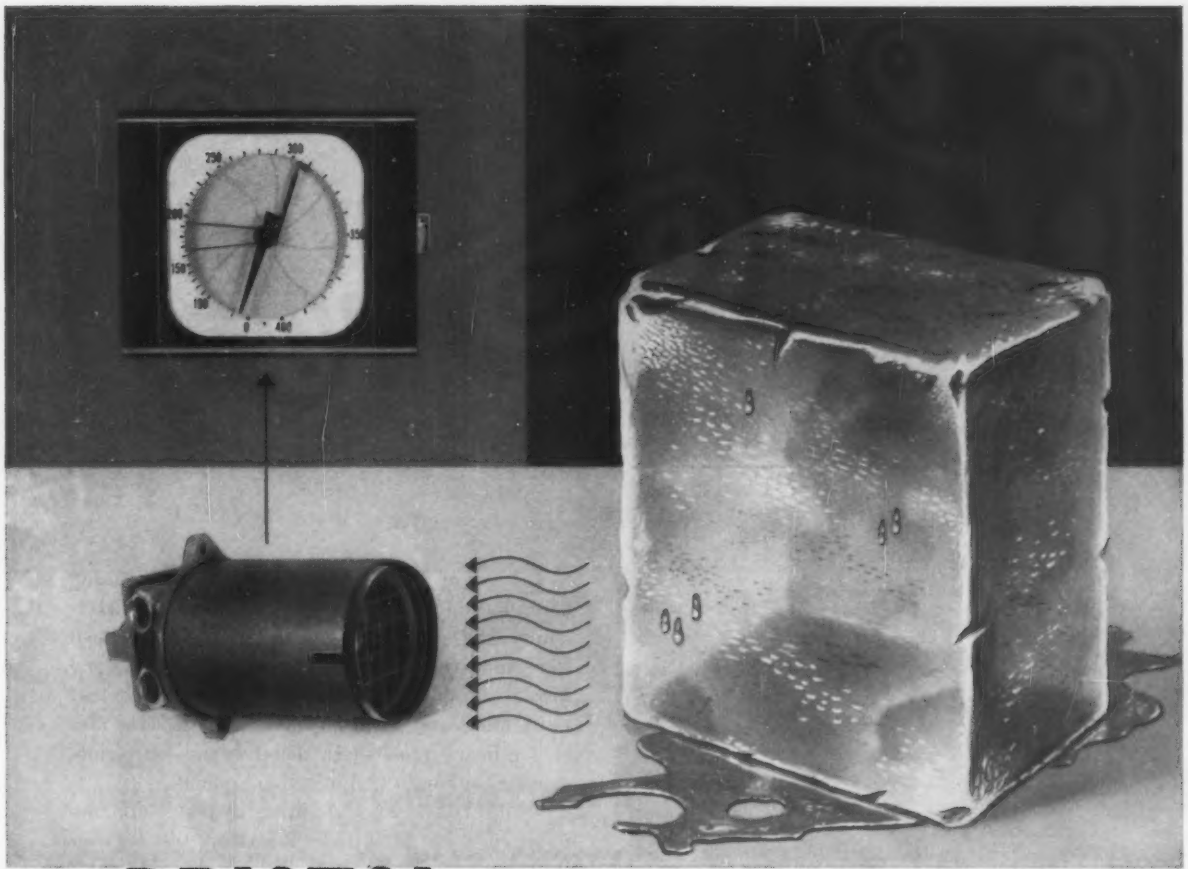
Makes Higher Heat Resistant Concrete

Haydite aggregate used with Lumnite cement produces refractory concrete suitable for sustained temperatures up to 1800-2000° F., which makes it excellent for tubular heaters, ducts, flues, stacks and catalytic crackers. Weighing from 30 to 40 per cent less than ordinary aggregate concrete, Haydite is exceedingly strong. It has excellent insulating properties and withstands pressures of up to 1130 pounds per square inch. Write today for free folder and complete information about Carter-Waters Refractory Haydite.

We sell direct to you.

CONSTRUCTION MATERIALS
CARTER-WATERS
KANSAS CITY CORP. MISSOURI
2440 Pennway Phone GRand 1-2570

For more data on advertised products, use Readers' Service Cards, last page.



new BRISTOL low-range radiation pyrometer

IDEAL FOR NO-CONTACT, CONTINUOUS TEMPERATURE MEASUREMENTS ON

Rubber	Plastics
Synthetic rubber	Carpeting
Tile	Mineral aggregates
Roofing shingles	Chemical flows
Adhesives	Petroleum flows
Blackened or unpolished aluminum	Beverage flows
	Reactor kettles
Textiles, synthetic and natural fibres	Mill rolls
	Furnace or oven charges or exteriors
Paper	Foundry molds

...and many other substances; web processes or products; conveyed, rolled or extruded products; and stationary objects.

0-200° F and other ranges to 1100° F • Direct reading charts, scales in F or C • Calibrated interchangeable head units • Automatic built-in ambient compensation • Easy emissivity compensation

Here's the first radiation pyrometer that really gets down to 0° F.

It's the Bristol Velotron Pyrometer System—so sensitive you can sight the radiation unit (at lower left above) on your hand and get an accurate temperature indication.

And on the high end, spans and ranges are available up to 1100° F or corresponding ranges in degrees Centigrade.

Charts and scales are direct reading, in degrees F or C, even on the lowest ranges. No laborious calibration runs, calculations; no curve consulting needed! And you get famous Bristol Dynamaster* Recorder accuracy —proven in thousands of installations.

Ambient temperature compensation is automatic, completely contained in recorder unit (no third unit needed), and allows use in ambients up to 135° F.

A simple knob adjustment allows compensation for emissivity characteristics of target material from black body on down.

Interconnection cables are standard copper wire; no special, preselected lengths required.

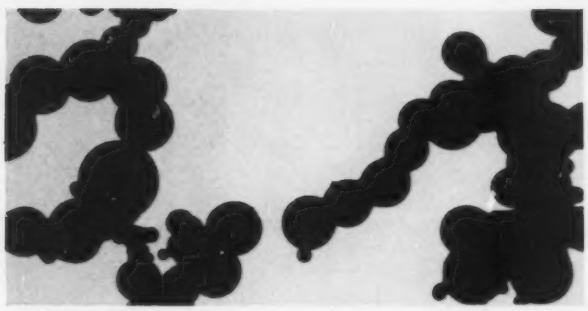
Write for complete technical data on this outstanding new Bristol contribution to industrial pyrometry. The Bristol Company, 111 Bristol Road, Waterbury, Conn. 9 31

*T. M. Reg. U. S. Pat. Off.

BRISTOL...for improved production through measurement and control

AUTOMATIC CONTROLLING, RECORDING AND TELEMETERING INSTRUMENTS

NEW FROM TRETOLITE.....



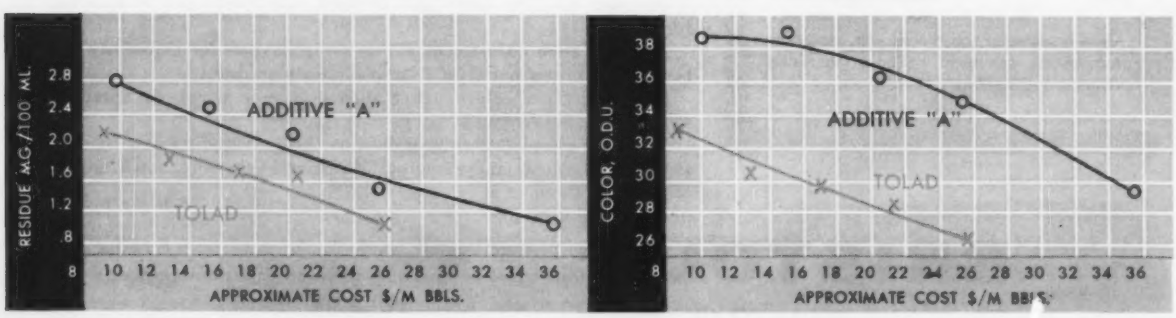
Above photomicrographs (magnification 6000X) show fuel oil samples after 12-week oven storage test. The upper photo is of a sample containing no additive, the lower sample photo contains TOLAD at commercial concentration. Note the fine particle dispersion attained by TOLAD Fuel Additive.

The use of TOLAD* Fuel Additive, by preventing deterioration of fuels in storage, enhances marketability and reduces customer complaints. TOLAD Fuel Additive prevents the formation of sludge and insoluble residue, the causes of fuel plugging in fuel lines, filters and burner tips. Insoluble residue also is a primary problem in diesel engine operation, causing fouling in fuel injection systems.

While TOLAD Fuel Additive is just being announced, it has been under laboratory test for over five years, and under controlled commercial testing for two years. As a result of these commercial use tests, six different refiners now use TOLAD on a routine basis. TOLAD Fuel Additive has been approved for use in diesel engine fuel by leading railroads.

One of the most important advantages of TOLAD Fuel Additive is its low cost. In two years of commercial use tests, TOLAD not only provided comparable *or improved* fuel stability for the fuels tested, but it consistently did so at a substantial cost advantage over the additive it replaced.

The graphs below illustrate the economic advantages of TOLAD over a well-known commercial additive. On fuel samples stored for 12 weeks at 110° F, the TOLAD-protected fuels showed less residue and better color, and always at a lower cost.



For more data on advertised products, use Readers' Service Cards, last page.

TOLAD® FUEL ADDITIVE

FA-60-1

added to domestic heating and diesel oils, TOLAD *improves their storage stability by . . .*

1. INHIBITING FORMATION OF INSOLUBLE RESIDUE

2. PREVENTING SLUDGE FORMATION

3. MAINTAINING COLOR STABILITY

TOLAD Fuel Additive is offered in a variety of formulations, all being ashless. TOLAD formulations are available, depending on the fuel oil characteristics, as inhibitors, inhibitor-dispersants, inhibitors with metal deactivator or inhibitor-dispersants with metal deactivator.

The Tretolite laboratories will test your fuel and recommend the TOLAD formulation most appropriate to insure stability improvement.

For complete information, ask any Tretolite refinery service engineer, or write to

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NETHERLANDS: F. E. C. Jenkins, Hoefbladlaan 134, The Hague
PERU: Oilfield Import, S. A., Apartado 71, Talara
TRINIDAD: Neal and Massy, Ltd., P. O. Box 544, Port of Spain

Equipment . . .

Chart Compares Wire Mesh Entrainment Separators

A handy new chart gives the density, style and use of wire mesh entrainment separators, mist eliminators or demisters. Style numbers and type names used by major maunfacturers of these products are listed, allowing comparison of density and mesh structure to be made. Style numbers are shown for all standard and special purpose meshes in the company's line. Schuyler Mfg. Corp.

Circle E6 green card, last page

36-Page Butterfly Valve Catalog Has Design Data

A comprehensive 36-page catalog on Darling-Pelton Rubber Seated Butterfly Valves and operators has just been issued.

The Catalog contains complete information on the line of valves, which are designed in accordance with American Water Works Association specifications, and for hydrostatic operating pressures up to 125 psi and velocities up to 16 feet per second. Also included is data on construction and design, dimensions, directions for ordering, general hydraulic data, materials and methods of operation. Darling Valve & Mfg. Co.

Circle E7 green card, last page

Diaphragm Valve Handles Catalysts And Pellets

A new rubber-diaphragm peristaltic-type discharge valve which makes it possible to handle coarse abrasives such as catalysts, pellets and other odd shaped materials unable to pass through conventional rotary valves, is available.

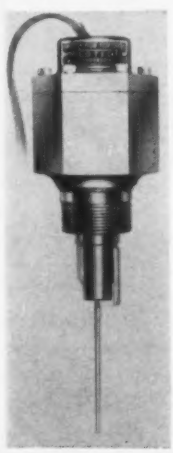
The valve's elliptical body and "sandwiching" of its sheet rubber diaphragms insure positive closure. Movement is confined to the valve's gum rubber diaphragms which alternately open and close by air pressure or vacuum. This action permits discharge of materials in measured quantities with a 100 percent air tight seal. There are no internal wearing metallic parts in the peristaltic valve and its rubber diaphragms are easily replaced.

Another distinctive feature is its "fail-safe" operation. Should either of the rubber diaphragms rupture, the other diaphragm is capable of extending to the opposite side of the valve for complete and positive closure. U. S. Hoffman Machinery Corp.

Circle E8 green card, last page

Magnetic Switch Provides Automatic Flow Control

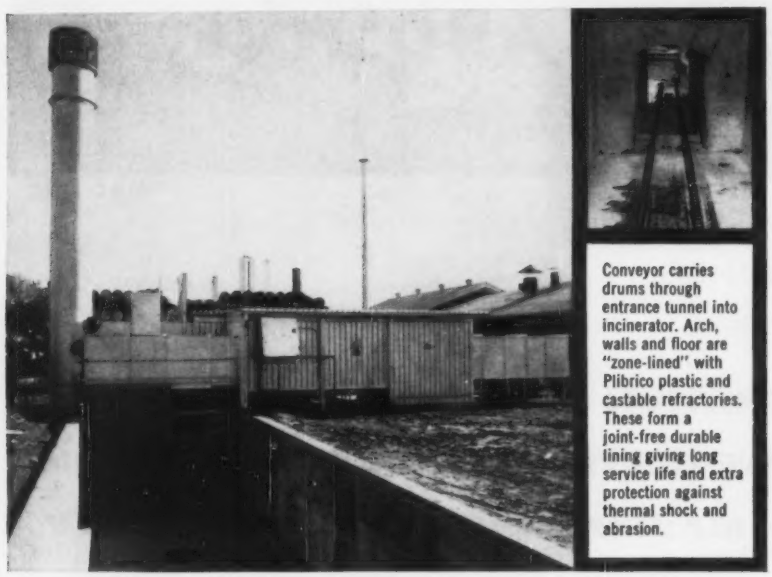
A new vane-operated but magnetically-actuated electrical flow switch that is completely sealed from piped product has been announced.



Responding only to product flow, this new switch has been subjected to four years of exhaustive field tests by 36 large pipeline companies. It has proved accurate, sensitive, simple, rugged and requires no expensive up-keep or repairs.

It has many applications wherever liquids are moved through pipes, such as—protection of pumps against loss of line flow, automatic starting of auxiliary pumps, signaling flow or no-flow conditions and locations, an interlocking switch for secondary protection of pumps, protection against breakdown of automatic programing in process plants, providing fully automatic stop-start protection of pumping units.

The Flotect Magnetic Monitor is a vane-operated switch that mounts directly into the line, is adapted to all sizes of pipes, withstands 2,000-psi working pressures, and features positive magnetic actuation. It has no troublesome bellows or mechanical linkage, and the vane responds to as little as 0.5-ounce



Conveyor carries drums through entrance tunnel into incinerator. Arch, walls and floor are "zone-lined" with Plibrico plastic and castable refractories. These form a joint-free durable lining giving long service life and extra protection against thermal shock and abrasion.

New Plibrico Incinerator at J. & B. Smith Co.

"burns" metal drums clean

...SAVES $1100 A WEEK!

Now, tough to clean 30 and 55 gallon drums caked with oil, paint, bituminous or other products are cleaned faster, safer and for less cost. Upended drums are conveyed through the Plibrico incinerator at the rate of 120 an hour, where controlled heat burns out the unwanted materials which drop into a collection pit.

Smoke-and odor-free cleaning. Prior to the installation of this new Plibrico incinerator all drums had to be transported and open-burned outside the city because of obnoxious smoke and fumes. All this expensive handling was eliminated with the Plibrico incinerator.

WRITE NOW FOR DETAILED CASE HISTORY . . . ask your local Plibrico Field Engineer to show you how modern incineration solves other reclamation and waste disposal problems in your field.

Plibrico INCINERATORS

PLIBRICO CO., 1812 Kingsbury, Chicago 14 • Canadian Plant: New Toronto, Ont.

Plibrico Sales and Service Throughout the World

REFRACTORY PRODUCTS • ENGINEERING • CONSTRUCTION

• The Skelly Oil Company kept the area around these butane-propane storage tanks completely free of weeds for a whole season by spraying the ground with Du Pont "Telvar".

Get season-long control of fire-hazardous weeds —spray once with a Du Pont Weed Killer

No fire hazard here from weeds. No expensive or difficult weed-control program, either. Just a simple weed-control maintenance program with a Du Pont weed killer kept the area around these storage tanks clean. One spraying of Du Pont "Telvar" monuron or "Karmex" diuron weed killers provides safe, economical weed control around refineries, storage tanks, pipelines and producing fields for a season or longer. Fire hazards are eliminated.

Five-year records of several petroleum companies show that Du Pont "Telvar" and "Karmex" cut weed-control budgets from 50 to 75%. "Telvar" and "Karmex" are non-flammable, non-volatile, non-corrosive and low in toxicity to man and animals. Contact Du Pont for information on which weed killer is best suited to your soil type and moisture conditions—write Du Pont, 2543 Nemours Bldg., Wilmington 98, Delaware; in Canada: Du Pont of Canada Ltd., P. O. Box 660, Montreal, Quebec.

On all chemicals, always follow label instructions and warnings carefully.

DU PONT
REG. U. S. PAT. OFF.
BETTER THINGS FOR BETTER LIVING
. . . THROUGH CHEMISTRY

Weed and Brush Killers

TELVAR* monuron weed killer · **KARMEX*** diuron weed killer · **AMMATE* X** weed and brush killer · **TRYSBEN* 200** weed killer · **DYBAR*** fenuron weed and brush killer

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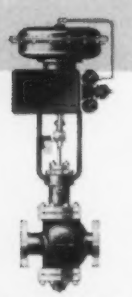
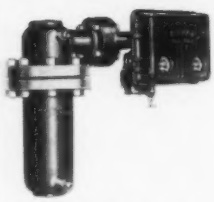
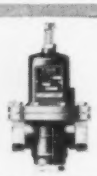


Type 657-A with 3500 positioner

Type 4150 and 4160 Wizard II Pressure Controllers

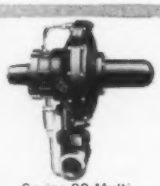


Series 2500-249 and 2500-259B Level-Trols



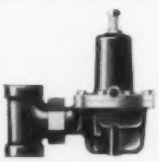
Type 95-H Pressure Reducing Valve

Type 630 "Big Joe" Field Regulator

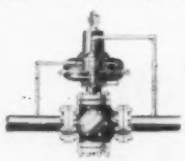


Series 99 Multi-Purpose Gas Regulators

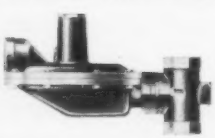
Type 655-A Pressure Regulator



Series 620 and 621 Farm Tap Regulators

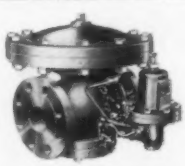


Series 298T Gas Regulators



Series S100 and 730 Service Regulators

Series 67FR Combination Filter-Regulator



Type 92B Pilot Operated Steam Reducing Valve

This "supermarket" availability of Fisher Control Valves and Controllers makes your delivery problems a thing of the past. Fisher keeps a stock of the equipment at left always on hand ready to ship to you at hourly notice. This means emergency requirements are met without costly delivery delays. This stock of control equipment includes all the most popular types in standard sizes.

In addition to the large factory stock, the Fisher offices in the column to the right which are starred carry a big selection of Fisher equipment in inventory to assist you.

Fisher constantly reviews the stock carried in the Supermarket and adds new items from time to time when your needs indicate.

Phone, wire or TWX (Marshalltown 578 or 579) and Fisher will have your order en route in a matter of hours, Saturday and Sunday excepted.

IF IT FLOWS THROUGH PIPE ANYWHERE IN THE WORLD...CHANCES ARE IT'S CONTROLLED BY...

FISHER GOVERNOR COMPANY

Marshalltown, Iowa / Woodstock, Ontario / London, England

CONTINENTAL EQUIPMENT CO. DIVISION, Coraopolis, Pennsylvania

FISHER® Controls

SINCE 1880

Now, for emergency needs contact FISHER or the representatives listed below.

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Vinson Supply Company
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Joseph W. Eshelman & Company
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Clarence B. Petty & Company
BUFFALO
W. J. Sommers Company
*CALGARY-EDMONTON
Barber Engineering & Supply Company
CARACAS, VENEZUELA
Sinclair Spence
*CHARLOTTE
Robert E. Mason & Company
CHICAGO
General Meters & Controls Company
CINCINNATI
H. T. Porter Company
*CLEVELAND
A. E. Ehrke & Company
*DALLAS
Vinson Supply Company
*DENVER
Joy & Cox, Inc.
*DETROIT
DuBois-Webb Company
*HOUSTON-CORPUS CHRISTI
Puffer-Sweiven Company
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*SHREVEPORT
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Northern Columbia Process Equipment Company
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Mechanical Valve & Engineering Spec.

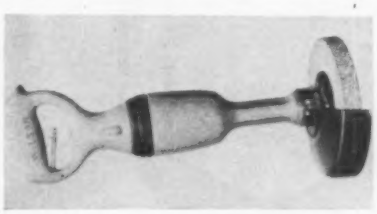
Equipment . . .

force. It is safe and explosion-proof, the pipeline product being entirely sealed from the electrical compartment. Compact in design, its total length, excluding vane, is only 7½ inches. The monitor has a standard spdt contact arrangement with a rating of 5 amps, 125-250 volts AC, but can be adapted to 440 volts AC. It has a contact life of 1 million operations, and features easy maintenance because design permits quick removal of electrical elements for inspection without shutting down pipeline operations. W. E. Anderson, Inc.

Circle E9 green card, last page

Portable Pneumatic Grinder Available In 8-Inch Size

A new 8-inch model portable pneumatic grinder features lightweight one-piece aluminum housing construction;



one-piece hardened and ground spindle; four prelubricated and sealed spindle bearings; steel inserts in all housing-threaded holes and bearing bores; and a hardened, ground, and hone cylinder. Thomas C. Wilson, Inc.

Circle E10 green card, last page

Tape Mechanism Records 96,000 Digits Per Second

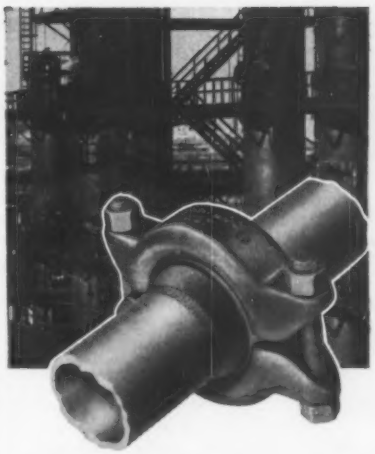
A new high-speed magnetic tape transport that is designed to greatly increase the life expectancy of magnetic tapes

used with electronic data-processing systems, has been developed.

The tape transport reads or records information at 96,000 decimal digits per second. Several of these units may be used simultaneously to supply or receive information at the tremendously high rate necessary to keep the system's central computer busy.

The tape mechanism will be standard on the new 800 high-speed data-processing systems currently being readied at two Boston area plants for commercial production and delivery to customers in October 1960.

The tape is driven 120 inches per second, in either direction, and is capable



GRAYLOC Connections Hold High Pressures With No Leaks During 197,000 Loading Cycles

GRAYLOC connections in use at a Texas chemical plant* were cyclically loaded with pressures from 2,500 to 9,000 psi 197,000 times without a leak. Although these connections are rated at 12,000 psi, two of them were tested at maximum static pressure to learn whether fatigue action had changed the ultimate capacity. Both held at pressures far exceeding rating and one held without leakage to 27,000 psi.

When high pressures are your problem, specify GRAYLOC connections for safety, low initial cost, low maintenance cost. Write for the whole technical GRAYLOC Test Data story today.

*Taken from a letter in our files

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P. O. BOX 2291 HOUSTON, TEXAS
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P. O. Box 2291 Houston, Texas
Please send me the GRAYLOC Test Data.
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Title_____
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City_____ State_____

of reading or recording as many as 96,000 decimal digits (numerals) or 64,000 alphanumeric characters per second. It has a rewind speed of 360 inches per second.

The system has almost instantaneous response to start and stop commands. It commences to move, on receipt of a command, in slightly less than one millisecond, and in 2.7 milliseconds is traveling at full speed. The tape moves substantially less than 0.3 inches on deceleration before it comes to a complete stop. Minneapolis-Honeywell Regulator Co.

Circle E11 green card, last page

New Insulation Material For Process Temperatures

"Zebra" is the name of a startling new insulating material just developed. It is described as a multi-layer, sectional-type thermal insulation primarily composed of calcium silicate-asbestos fiber bonded felts. It is designed for temperatures ranging from 200 to 1,200° F.

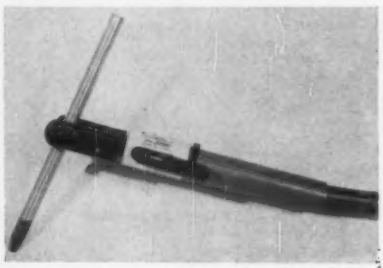
For pipe sizes ½ to 6 inches in diameter it is available in nominal thicknesses of 1 to 4 inches. For pipe 7 to 24 inches in diameter, it is available in thicknesses of 1½ to 4 inches. The material comes in sectional and tubular form.

In addition to greater resistance to shock, other qualities of the new insulation include improved handling characteristics plus easier installation in single-layer thicknesses in sectional form for pipe up to 24 inches in diameter. Keasbey & Mattison Co.

Circle E12 green card, last page

Electrode Torch Removes Large Areas of Metal

A new heavy-duty manual torch model is available to industries whose work requires the use of large-size electrodes, ⅝ and ¾ inch, for fast removal of large



areas of metal. Like other torches in the line, it uses the heat of an electric arc to melt metal, and simultaneously a stream of compressed air to blow it away.

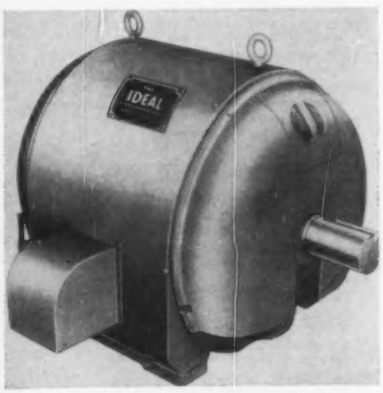
The H-6 is well insulated to insure maximum life. The forward section of the torch handle and the positionable head both have a protective sleeve of silicone glass laminate. A special rubber boot provides a safety cover for the electrical connection on the end of the torch concentric cable. The Arcair Co.

Circle E13 green card, last page

High-Speed Motors Offered In Wide Horsepower Range

New high-speed squirrel-cage induction motors are being offered in the 100-5,000-HP and 514-3,600-rpm range.

A one-piece, wrap-around steel plate



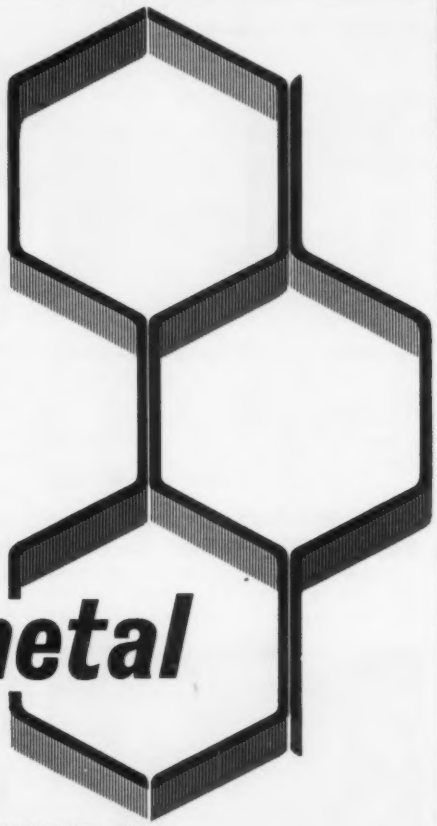
cover running the full length of the frame extends well below the center-line of the motor on each side to provide natural drip-proof protection and to increase the rigidity of the frame structure. The double-end ventilation system provides maximum cooling, permitting full utilization of motor capacity.

Motors are available with silicone rubber as well as class A, B and H insulations.

A patented oil-lubricated bearing, sup-

HOW MANY YEARS WILL A GOOD LINING LAST?

Make it with Hexmetal



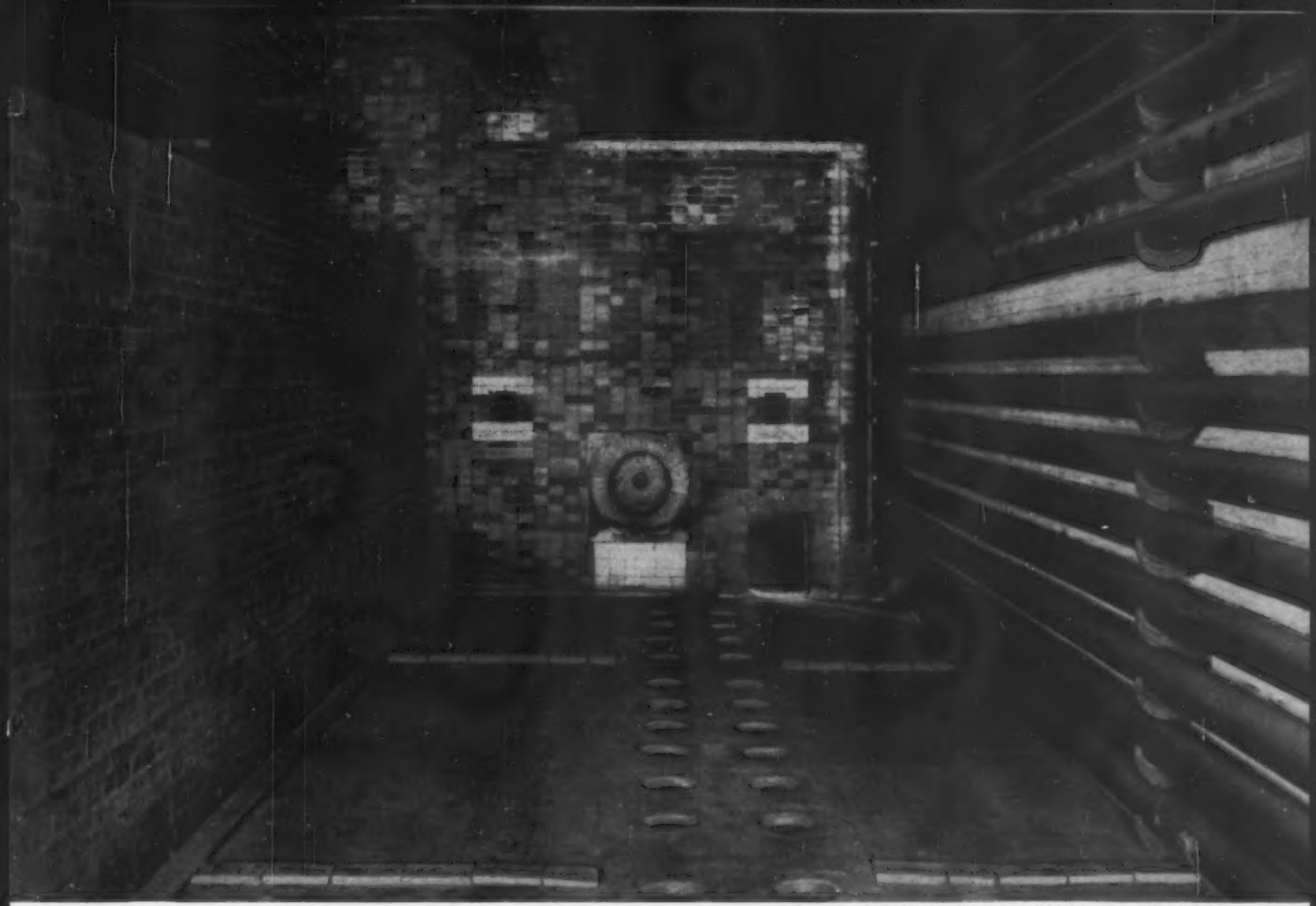
AND DOUBLE THE NUMBER YOU FIRST THOUGHT OF

A lining lasts as long as its bonding properties.

The natural organic bond of refractory clays and the chemical set of concrete all fail eventually under the stresses imposed upon them. When a lining is "bonded" or given "bone" by Hexmetal Reinforcement, it holds in position long after all its natural bond is burnt out by heat or chemical action. The independent pinned joint of Hexmetal cells give twice the life of other reinforcements with lug joints.

Industry is year by year proving the value of these claims in Flues, Ash-Pits, Reactors, Cyclones, Cat Crackers, Coke Hoppers, Down Comer Pipes, Hydroformers, Water Turbine Flumes, Underground Galleries, etc.

CAUSEWAY REINFORCEMENT LIMITED
Five Ash Works • Dover Road East • Northfleet • Kent
Cables: HEXMETAL, GRAVESEND
Telephone: GRAVESEND 7871/3



Interior of Oil Heater Lined with B&W Insulating Firebrick.

B&W Refractories stay on stream

Long refractory life, low furnace maintenance, and dependable service result from the use of B&W Refractories. B&W offers a wide line of *specialized* refractories *engineered* to give you maximum furnace availability and economy.

Naturally, the refractory selected depends on the specific service. B&W Insulating Firebrick, for example, serve a dual role. First, these durable, lightweight IFB are most efficient insulators, and second, they withstand direct exposure to furnace heat. This means . . .

REDUCED CONSTRUCTION COSTS—The lightweight and high insulating value of B&W IFB combine to lower material costs and simplify furnace design. Because they withstand furnace heat, they eliminate the need for dense refractory constructions backed up with insulating materials. This, together with lightweight, means thinner, lighter wall constructions, often providing savings in structural steel and foundation costs.

REDUCED OPERATING COSTS—The high insulating value of B&W IFB means savings in everyday operation. Per inch of thickness, B&W IFB provide more insulation than any other refractory lining. Less heat is lost, casing temperatures are lower, working conditions are improved and efficiency is increased.

Furthermore, since B&W IFB are light in weight, they store and conduct less heat. Heavy refractories retain heat; in the event of forced shutdown, they can cause burn-out of expensive alloy tubes, where used. The low quantity of heat stored by B&W IFB can be quickly dissipated, thus protecting these expensive tubes.

This low heat storage also permits faster heating and cooling. This means quicker access to the furnace in the event of emergency shutdown. Your maintenance crew can get in the furnace sooner and get it back on stream faster.

Consult your B&W Refractories Representative for assistance with your refractories problem or write to The Babcock & Wilcox Company, Refractories Division, 161 East 42nd Street, New York 17, N. Y.

B&W

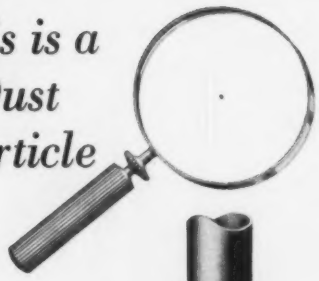
THE BABCOCK & WILCOX COMPANY

REFRACTORIES DIVISION

R-628

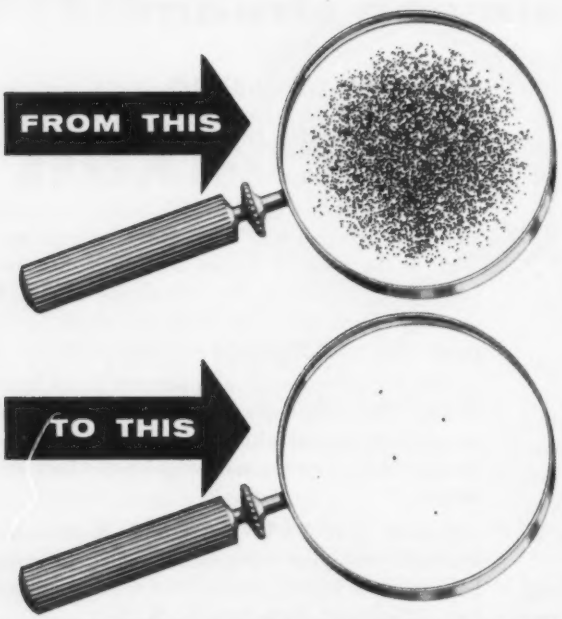
B&W Firebrick, Insulating Firebrick, and Refractory Castables, Plastics, Ramming Mixes, Mortars, and Ceramic Fiber.

This is a Dust Particle



This is a Cyclo-trell Dust Collector →

The Cyclo-trell Dust Collector Cleans Gas with these Dust Particles...



Result: Efficiencies Exceeding 98%

This is a fact. If you have a process or cleaning problem in steel mills, refineries, paper, cement or chemical plants, call on Research-Cottrell. • We will be glad to consult with you on your specific dust collection problems, and place at your disposal the largest research and engineering facilities.

For further information, write for Bulletin 300 which describes several applications in detail.

Research-Cottrell, Inc.

RESEARCH COTTRELL INC TRADE MARK

Main Office and Plant: Bound Brook, New Jersey

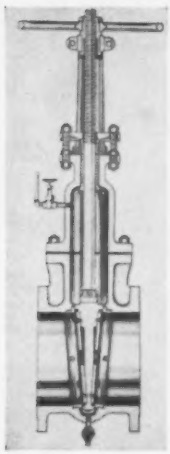
Representatives in major cities of U. S. and Canada

RC-205

plied on squirrel cage induction motors provides unrivalled long life, cool operation and high load-carrying capacity. As a result of this feature plus the unique split-type bearing bracket, a valuable reduction in maintenance costs can be realized. Bearing replacement, when inspection proves necessary, can be accomplished without uncoupling the motor, disconnecting leads or disturbing motor or coupling alignment. Ideal Electric & Mfg. Co.

Circle E14 green card, last page

Tight Seat Check Made On Closing Gate Valve



The new Block-Bleed-Test valves feature dual metal-to-metal and elastomer seals. A simple visual-proof test upon each closure of the valve permits the operator to verify the effectiveness of seat tightness. Designed to outmode the use of auxiliary line blinds, this non-lubricated gate valve will perform efficiently and economically in services handling light gases or heavy fluids within a temperature operating range of —40° F to + 400° F. Absolute shut-off promotes operational safety and eliminates the possibility of product contamination. Valves are available in sizes ½ to 24 inches in the 150-pound series, and 1½ to 16 inches in the 300-pound series. Pacific Valves, Inc.

Circle E15 green card, last page

Graphite Separator Collects Corrosive Liquids From Gas

Entrainment separator modules made of impervious graphite for effective separation of entrained liquids from corrosive gas streams are now available. Designed for high collection efficiency and low pressure drop, the corrosion-resistant modules measure one by two feet and can be easily assembled into banks to fit any duct or process vessel.

Type MV entrainment separator modules are of unitized construction, and operate on the principle of impingement plus venturi action. Staggered rows of tear-drop-shaped Karbate impervious graphite rods are cemented in place with a minimum of ¼-inch clearance to minimize clogging. The staggered arrangement prevents straight-through flow, and

BS&B's D and DV Rupture Discs, which are fully interchangeable in BS&B Safety Head flanges with conventional type pre-bulged discs, are engineered to give highly desirable Safety Head protection to those pressured systems in which one or more of the following "difficult" conditions prevail:

1. When operating pressure must be close to relief pressure.
2. When high operating temperatures are involved.
3. When alternating pressure and vacuum prohibits the use of standard one-layer rupture discs.
4. When pulsating pressure conditions prevail.
5. When a combination of metal and plastic disc construction is needed to obtain lower rupture pressures.

BS&B D and DV Rupture Discs have these advantages:

1. Fast action and unrestricted relief openings.
2. Wider rangeability in selection of metals and plastics for disc components.
3. Longer service life.
4. Rugged construction for added protection against possible damage by rough handling.

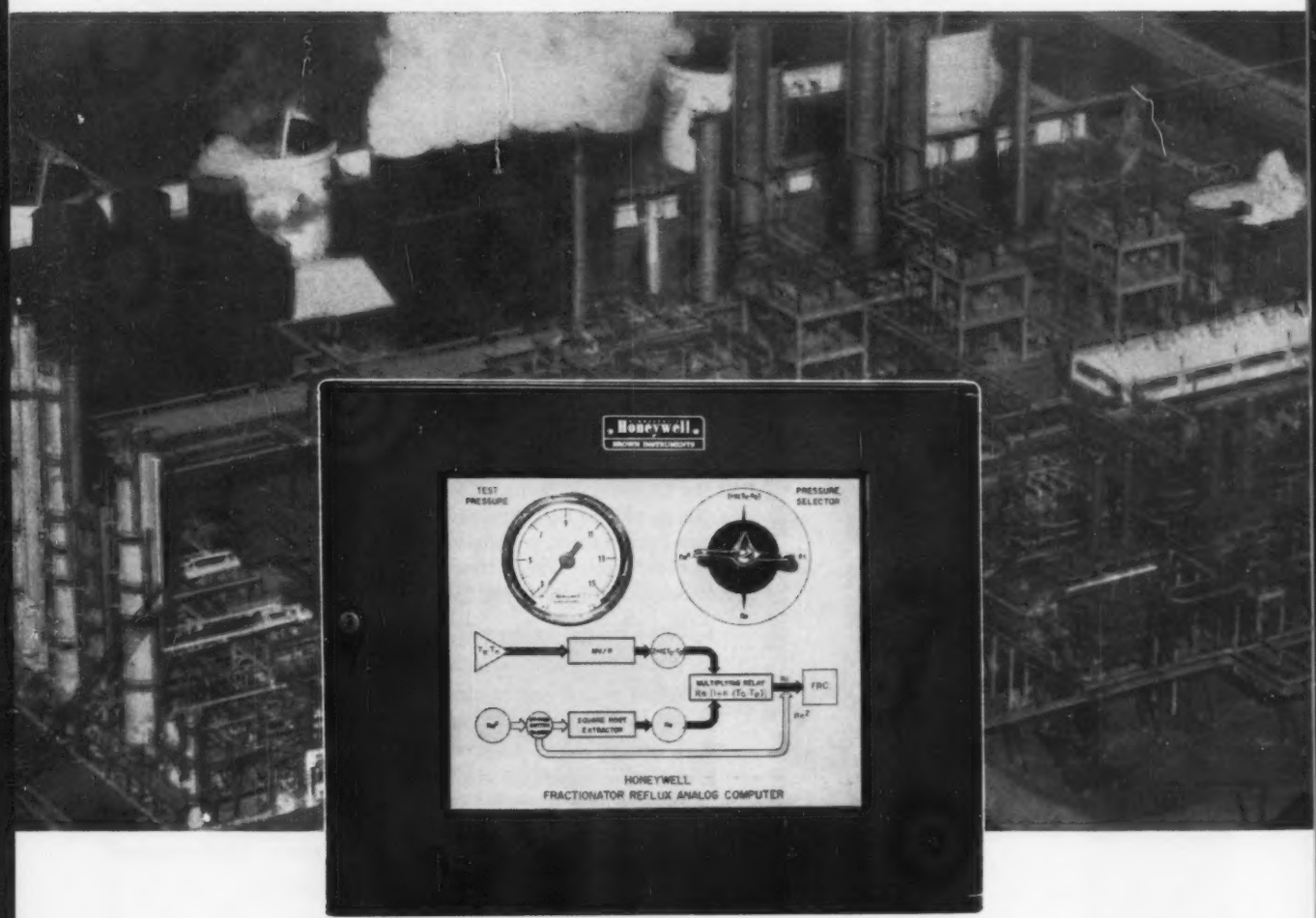
Let BS&B Safety Heads solve your pressure protection problems. Our engineers will gladly evaluate your pressure system to assist you in proper selection of Safety Heads.

BLACK, SIVALLS & BRYSON, INC.

Safety Head Division, Dept. 2-F2
7500 East 12th Street
Kansas City 26, Missouri
Telephone: BEnton 1-7200

For more data on advertised products, use Readers' Service Cards, last page.

Stabilize Fractionating with new Honeywell



HONEYWELL *FRAC* CONTROLLER IS EASY TO USE AND MAINTAIN

- Standard Honeywell components, packaged in a standard Honeywell strip chart recorder case—completely wired and internally piped.
- Only four simple, easily accessible process connections required to put the unit in operation.
- Chassis pulls out for front-of-case servicing, simplifying adjustment and maintenance for your instrument technicians.

COMPONENTS

MV/P (millivolt-to-pressure) Transmitter

- Fully transistorized
- Continuously sensitive to temperature change
- Constant voltage supply
- Simple span and zero adjustments

Pressure selector and test pressure gage

- Provide check of all pneumatic pressures within the computer for simplified trouble shooting.

By-pass switch

- Permits switching from *FRAC* control to conventional external reflux flow control.

Column Operation

*FRAC** Controller

- **Easily installed and maintained by present instrument technicians**
- **Savings realized justify installation**
- **Tamper-proof design**

This new Honeywell control system immediately adjusts column operation to the effects of ambient temperature on overhead product condenser and external reflux. It continuously computes internal reflux flow, to maintain the most efficient, economical fractionating tower operation.

The new method, originally developed and licensed by Phillips Petroleum Company, utilizes a simple Honeywell analog computer employing standard Honeywell electric and pneumatic instrument components.

By correcting instantly for temperature deviation, the new control system offers the following economies.

- Less reboiler heat is required, because large surges of internal reflux that would lower temperature are eliminated.
- Reduction in off-specification product minimizes re-runs and the need for intermediate storage.
- Closer control permits fractionator to operate closer to the flooding point.

Get complete details from your nearby Honeywell field engineer. Call him today . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL, Wayne and Windrim Avenues, Philadelphia 44, Pa.

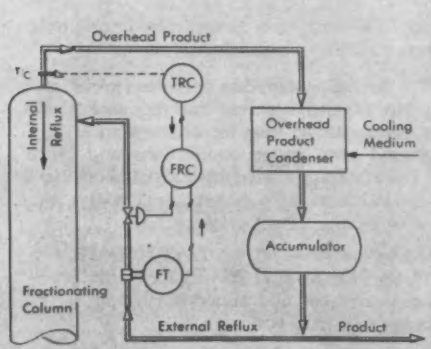
**Fractionator Reflux Analog Computer. Trademark, Minneapolis-Honeywell Reg. Co.*

from Honeywell... ANOTHER DIAMOND JUBILEE PRODUCT

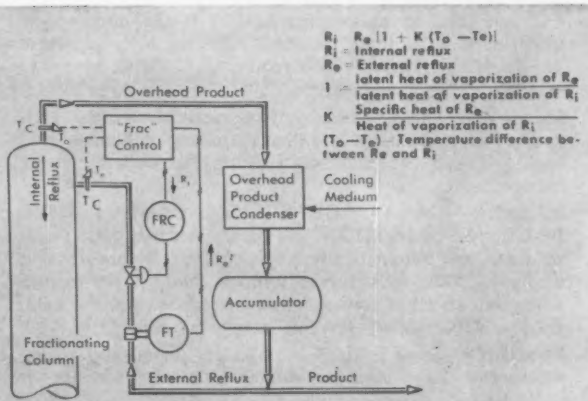
Honeywell

First in Control

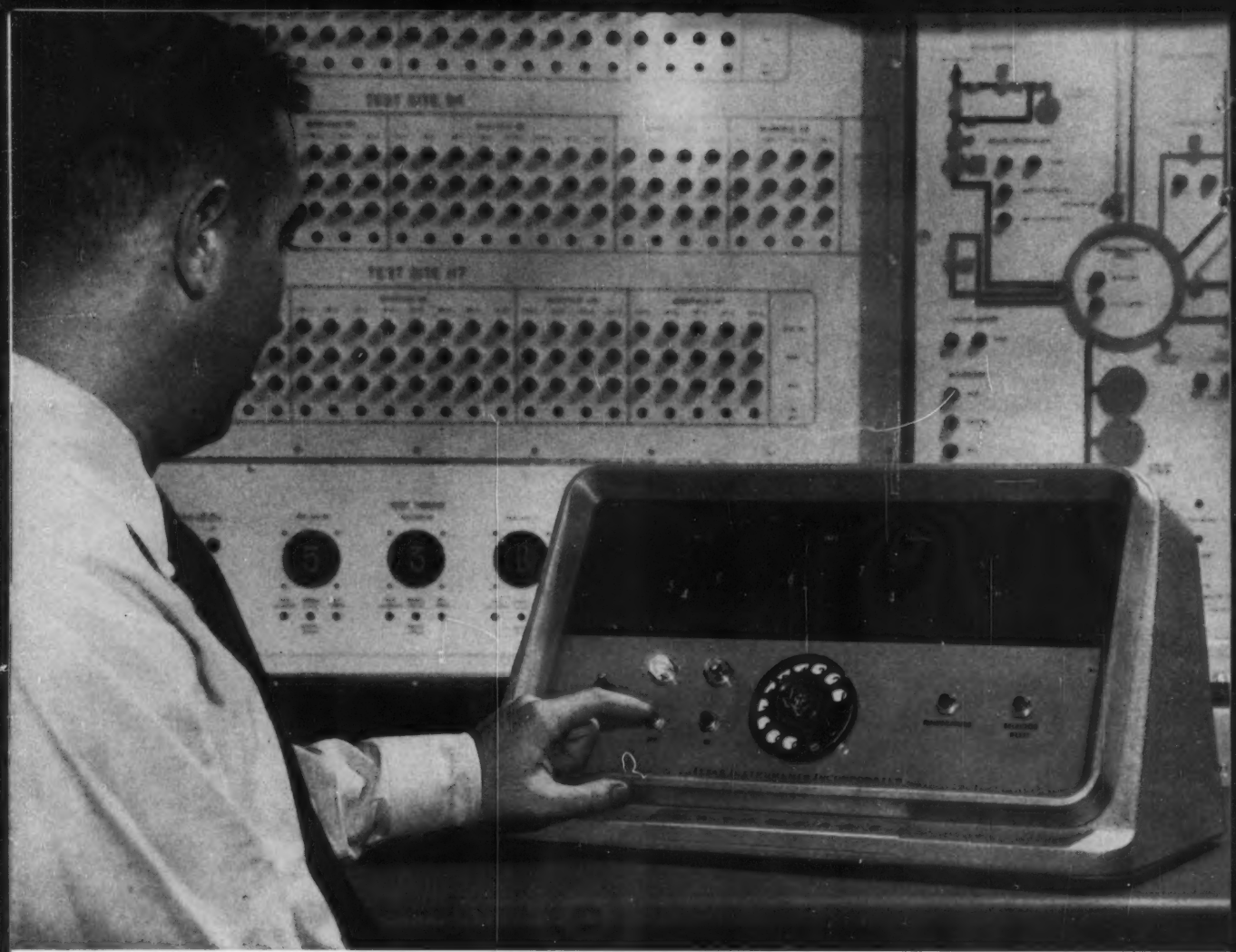
SINCE 1885



PROBLEM with existing fractionator control systems—Column is upset when temperature of external reflux is indirectly affected by changes in atmospheric conditions or in the temperature of the cooling medium to the condenser. Result: off-spec product, wasted reboiler heat, lower fractionator capacity.



SOLUTION: FRAC Controller (1) measures external reflux flow rate (R_e) and the temperature difference between the overhead product (T_o) and the external reflux (T_e); (2) computes internal reflux flow rate (R_i); and (3) holds it constant by adjusting external reflux flow rate to get most efficient fractionator



Use the only tank gauge system specifically designed for COMPLETE MEASUREMENT-ALARM-CONTROL

DATA-GAGE* system is the only field-proved tank gauge system that provides the multi-purpose functions of measurement, alarm and control without extra, expensive control and selector equipment. And, it is the only system that performs all these functions with the high degree of accuracy and reliability you require . . . check these outstanding features carefully:

Accuracy — DATA-GAGE system measures surface level to 1/16-inch accuracy in either stationary or floating roof tanks . . . is accepted for auditing purposes by major oil companies.

Reliability — DATA-GAGE SYSTEM CANNOT GIVE FALSE INFORMATION! All binary decimal code transmissions are automatically triple-checked before data is displayed. Float must break from the fluid surface to provide readout; point connections are verified from the field; polar code eliminates possible long-short ambiguity.

Versatility — *Same equipment* provides: digital and analog measurement including accumulator readout; control for motors, pumps, pilot valves, two- and three-position valves, adjustable chokes, controller set-points, etc.; alarm indication from any sensing contact. DATA-GAGE system can be provided with automatic programmers, data loggers, alarm and status displays.

Capacity — Up to 1000 tanks can be measured for liquid level and temperature with one standard system.

Economy — DATA-GAGE system has both low initial and long-range cost. No expensive extras are required. Code lines and power lines can be run in same conduit . . . often existing ground level gauge connections and pipes can be utilized. Transistors are used instead of short-lived vacuum tubes. Easy access plug-in units make this the easiest and safest to service of all systems.

For more detailed information on the DATA-GAGE system, request Bulletin No. M-601. If you have any problems in remote measurement and supervisory control, TI application engineers can help you.

TEXAS INSTRUMENTS
INCORPORATED
GEOSCIENCES & INSTRUMENTATION DIVISION
3609 BUFFALO SPEEDWAY • HOUSTON 6, TEXAS • CABLE: TEXINS

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the open diagonal lanes permit easy cleaning when necessary. The streamlined rod shape retards reintrainment and minimizes resistance to gas flow.

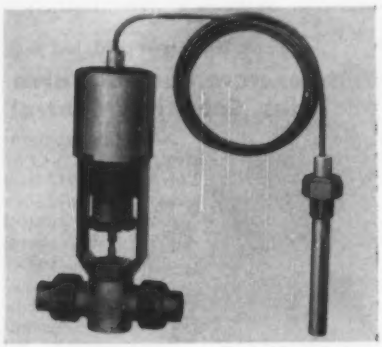
Modules are available in two styles. Style A is used in single-row entrainment separators or as the top row of larger assemblies; style B units for the lower rows have a gutter and downcomer to provide positive drainage of the liquid separated from the gas by upper units. Side plates for both styles provide proper fit to the wall of the containing vessel.

Approximate capacity of one module is the same as that of a 20-inch line-type entrainment separator. National Carbon Co.

Circle E16 green card, last page

Temperature Regulator Designed For Fired Heaters

A new self-powered temperature regulator especially designed for use on gas-fired petroleum heaters and treaters, is



available. The rugged device is built to withstand severe service conditions with minimum maintenance, and to provide reliable, accurate control.

The regulator bulb is equipped with a close fitting, tin plated steel-bulb well or socket to facilitate installation. The bulb can also be supplied without the socket.

The regulator valve has a Buna "N" disc, assuring bubble-tight closure. A polished stainless steel valve stem and "O" ring stem seal made of Buna "N" provide smooth, leak-free valve operation. A stem cleaner or wiper is provided to protect the "O" ring seal.

Valve sizes are ½-inch and ¾-inch. The temperature range is 110°-190° F. Robertshaw-Fulton Controls Co.

Circle E17 green card, last page

Pump Shaft Seal Designed Especially For Slurries

Information and engineering data on a new corrosive service shaft seal made of Teflon are contained in a bulletin just published. The seal described is designed to handle all concentrations of acids and salts, strong oxidizing or reducing agents and all organic compounds. These include sulphuric, nitric, and phosphoric acids and similar fluids. A bellows-type construction makes it specially suited for many slurry applications because it eliminates improper seal operation due to slurry build-up along the pump shaft. This design also allows maximum seal axial flexibility to compensate for pump shaft runout.

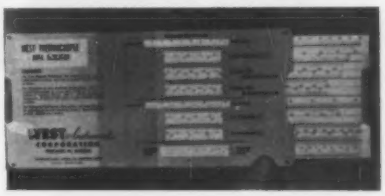
Known as the Type 20, the seal is available in two single-face types, one for internal and the other for external mounting, depending upon the application. A double-face type is also available for internal mounting only. Shaft sizes range from ⅝ to 3 inches. Seal size and operating temperatures determine the maximum operating pressure. For example, a ¾-inch seal will withstand 45 psi at 250° F to 150 psi at 70° F; and a 3-inch seal, 15 psi at 250° F to 80 psi at 70° F. Crane Packing Co.

Circle E18 green card, last page

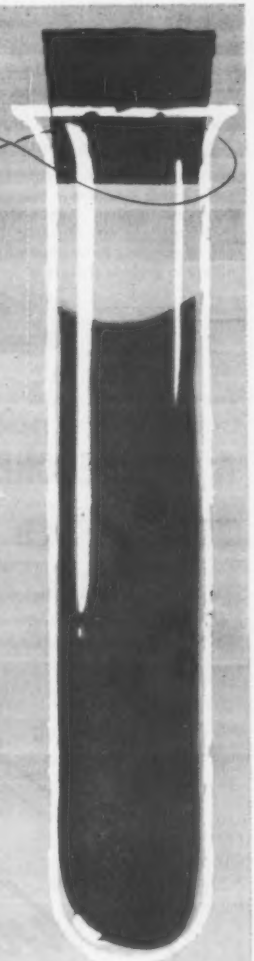
Graphic Calculator Gives Fast Thermocouple Data

An exceptionally useful graphic calculator giving thermocouple data has just been introduced.

Called the "Thermocouple Data Indicator," the calculator gives millivolt values for Iron-Constantan, Copper-



Customer Service Lab.
Floridin Company
P. O. Box 989
Tallahassee, Florida



We want OIL!

Send us some of your feed stock. Our Customer Service Laboratory will test your sample and recommend the proper grade of FLOREX® fuller's earth or FLORITE® activated bauxite to fit your refining needs. Let us show you the advantages of using these two quality mineral adsorbents to clarify, deodorize, decolorize, neutralize, and stabilize your feed stocks. There is no obligation.

Our quality controlled production methods assure the uniform high adsorptivity, uniform grain size and screen distribution of FLOREX and FLORITE in every shipment. These materials are available in a number of different grades for both percolation and contact refining and Floridin Company can provide excellent shipping service on your orders.

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☐ *Please give me more information on FLOREX, FLORITE and your Customer Service Laboratory.*

☐ *I am forwarding a sample (at least one quart) for testing. I understand there is no obligation.*

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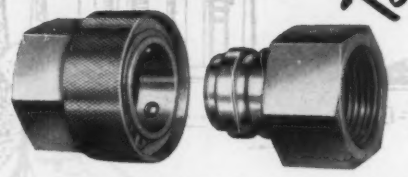
For more data on advertised products, use Readers' Service Cards, last page.

ALL-PURPOSE QUICK COUPLINGS BY *Roylyn*

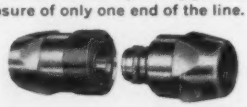


For the Petroleum and Petro-chemical industries, Airaterra offers the finest in hydraulic, pneumatic, and fluid couplings. Where quality, reliability, and positive performance are important, Roylyn Open Couplings are industry-approved and specified because they ensure:

- Full Flow
- Positive Lock
- Increased Efficiency
- Leak Proof Low & High Pressure
- Adaptability between like sizes
- Ease of Operation
- High Pressure Seal
- Stock Sizes from ¼" to 3"

Airaterra engineering and design makes possible the adaptation of these and other Roylyn couplings to meet your specifications.

ANOTHER POPULAR INDUSTRY-SPECIFIED ROYLYN COUPLING IS: **Self-Sealing Coupling** — featuring spring-loaded valves which automatically seal both ends of the line when the coupling is disconnected. Design flexibility allows a valved coupling to be used with an open Roylyn mating nipple to provide closure of only one end of the line.



DESIGNED • MARKETED BY AIRATERRA

For further information on these and other quality Roylyn products, write for Brochure No. AR-015 to:

AIRATERRA • 620 PAULA AVENUE • GLENDALE 1, CALIFORNIA "THE BEST CONNECTIONS IN THE WORLD"

A UNIQUE CHECK VALVE THAT'S UNSURPASSED IN WATER, AIR, OIL OR GAS SERVICE

SILENT • SEATLESS • LOW PRESSURE DROP

Technocheck©

OUTPERFORMS • OUTWEARS OTHER VALVES • COSTS LESS TO MAINTAIN

In field service in a wide range of water, gas, air and oil applications, Technocheck's performance and reliability are unsurpassed. Its exclusive design eliminates valve seats. Tight sealing, low pressure drop and long life with low upkeep are some of its important characteristics.

SCHEDULE OF STANDARD VALVE SIZES

GENERAL DESCRIPTION	PSI	SIZES
Cast Iron, Flanged	125	4", 6", 8"
Steel, Male Threaded Ends	150	1½", 2", 2½", 3"
Steel, Flanged	150	3", 4", 6", 8"
PVC, Male Threaded Ends	125	1½", 2", 3"
PVC, Flanged	125	2", 3"
PVC, Flanged	50	4", 6", 8"

We invite inquiries on other sizes and in special materials.

Techno Corporation Dept. PR
16 West 5th Street, Erie, Pa.

Equipment . . .

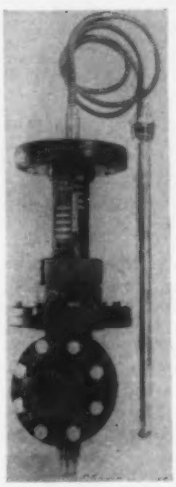
Constantan, Chromel-Alumel, Platinum 13 percent Rhodium-Platinum and Platinum 10 percent Rhodium-Platinum thermocouples for all temperatures within their range. It will indicate directly for readings based on a zero degree reference temperature or corrected to any ambient temperature. This makes the calculator especially valuable when used with potentiometer recorder calibration.

Other data given includes thermocouple and extension wire resistances; conversion of B&S wire gauge into both millimeters and decimal inches; pipe sizes including outside diameters and wall thickness for standard, extra heavy and double extra heavy pipe; Instrument Society of American wire type designations and color codes; maximum temperatures for common thermocouple protection tubes; thermocouple polarity; Fahrenheit-centrigrade conversion; and standard C and D scale slide rule.

"Thermocouple Data Indicators" are priced at $2.00 each. West Instrument Corp.

Circle E19 green card, last page

Temperature Control Valve Provides Sensitive Control

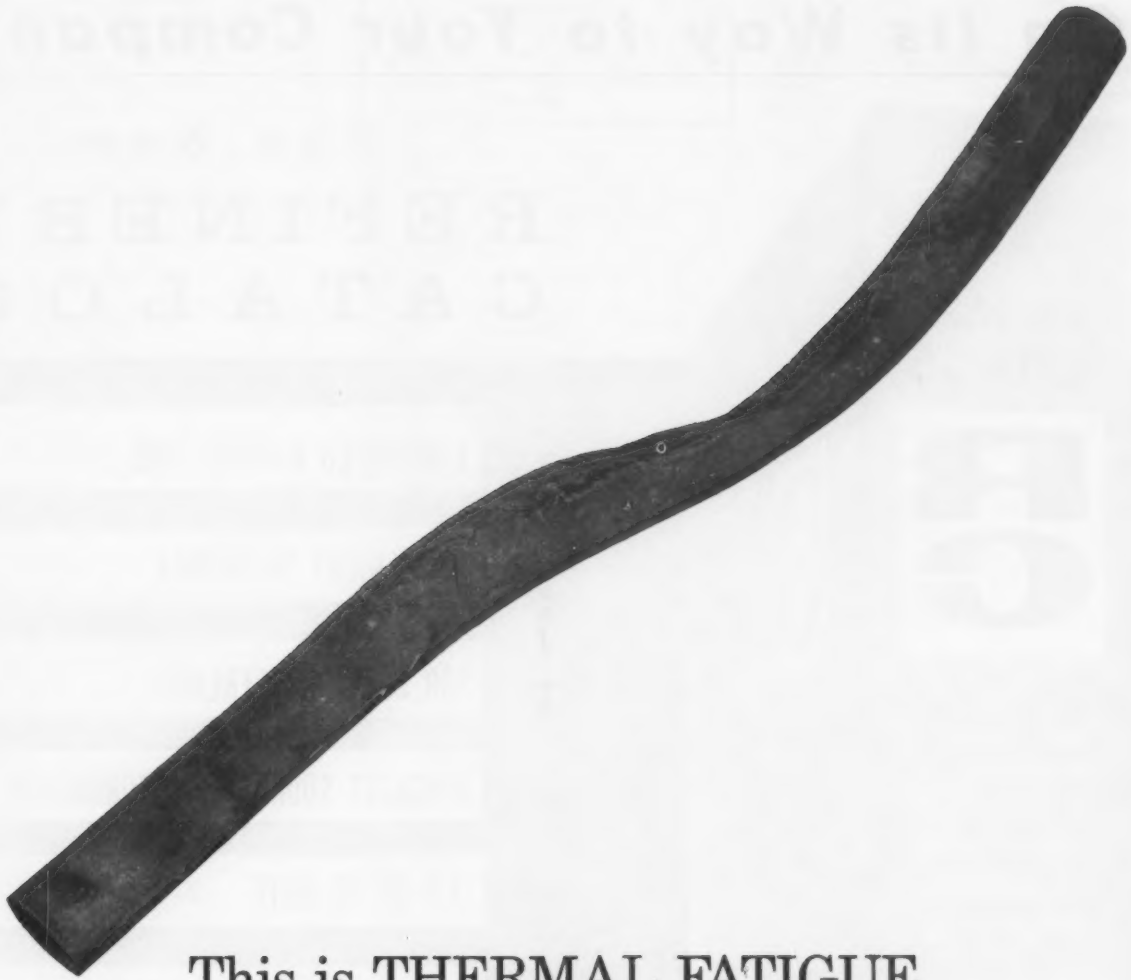


New piloted temperature control valves in ¼ to 2-inch sizes are available for sensitive control of rugged pressure drops. These valves are widely used in industry to control temperatures of instantaneous heaters, oil preheaters, storage heaters and process heating and cooling applications. Sliding-gate, self-lapping, self-cleaning seats insure positive tight shut-off during lock-up, and accurate regulation during operation. Available from stock in ductile iron (# 1180) and bronze (# 1280) bodies, the valves are suitable for pressures to 250 psi and temperatures to 500° F. They cover ten temperature control ranges from 35-450° F, and capacities from 12 to 6,600 pounds of steam per hour or 1 to 175 gallons of water per minute, depending on pressures. Capable of accurate control with a pressure differential across seats of 125 psi, the valves are suitable for heating or cooling applications. OPW-Jordan Corp. **Circle E20 green card, last page**

Equipment Catalog Released For Process Industries

A new catalog guide of equipment for the process industries has just been released.

Included in it are descriptions of compressors, vacuum, centrifugal, axial-flow and turbine pumps, and valves for fluid flow; crushers—grinding and roller mills



This is THERMAL FATIGUE

This photograph shows a heat-resistant furnace tube after thermal fatigue failure.

Thermal fatigue failure begins with cyclical temperatures and variable heat inputs. These conditions produce nonuniform thermal expansions and contractions. As a result, strong, hindered expansion and contraction stresses develop. These stresses produce plastic flow which results in the tube deformation shown above. Deformation of this type curtails furnace operations and constitutes thermal fatigue failure. Progressive deformation or severe thermal fatigue stresses will cause tube-rupture failures.

Thermal fatigue is an inherent problem in heat-resistant components, cast or wrought. As such, it occupies an important place in Electro-Alloys research efforts to lengthen life of components working under high temperatures and severe cyclical conditions.

We have created apparatus that assesses and analyzes the variables of thermal fatigue. Check with your Electro-Alloys representative for the meaning of our thermal fatigue data as it pertains to the material specification, design and service conditions of your heat-resistant components.

Send for free technical booklet on Thermal Fatigue

Please send me free copy of "The Mechanism of Thermal Fatigue," by Howard S. Avery—comprehensive report based on extensive lab studies:

Name_____

Title_____

Company_____

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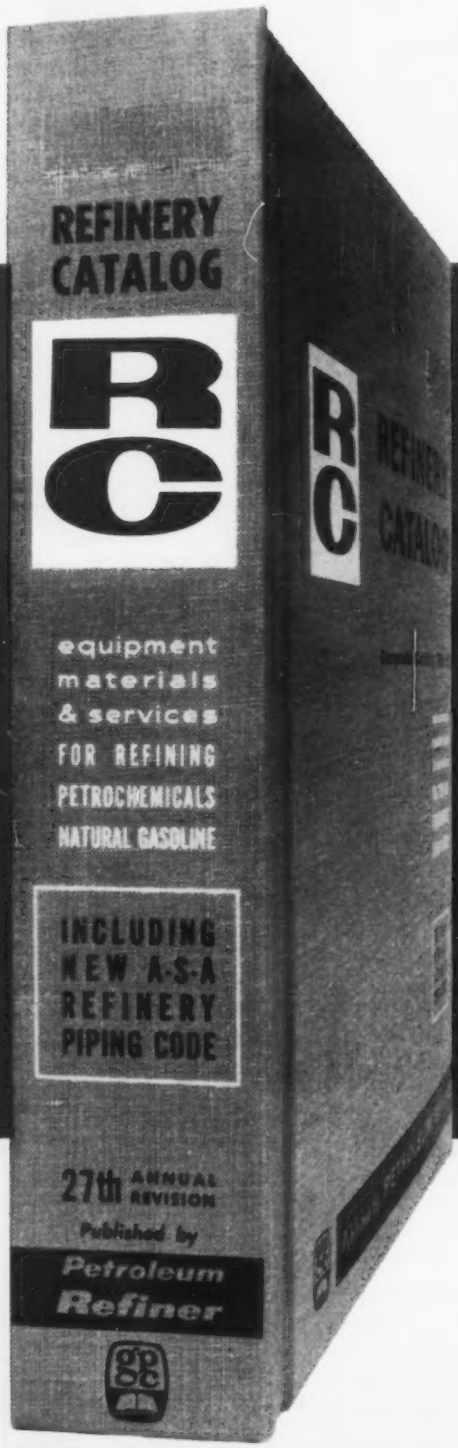
Electro-Alloys, 2202 Taylor St., Elyria, Ohio

AMERICAN Brake Shoe COMPANY

ELECTRO-ALLOYS DIVISION • Elyria, Ohio

For more data on advertised products, use Readers' Service Cards, last page.

On Its Way to Your Company



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On the opposite page you'll find a complete list of companies whose complete or condensed catalogs appear in the current REFINERY CATALOG. When you're looking for data on products handled by these companies, be sure to check your REFINERY CATALOG. It is the most complete single source of buying information available in one volume today.

JUST OUT!

THIS YEAR'S

For your convenience . . . these leading manufacturers and suppliers have filed complete or condensed catalog data in the 1960 Refinery Catalog.

ACF Industries, Inc., W-K-M Division
A. P. V. Paramount Ltd.
Adsco Division, Yuba Consolidated Industries, Inc.
Aerovent Fan Co., Inc.
Aerzener Maschinenfabrik G.M.B.H.
Aimco Products Corp.
Air Preheater Corp.
Airetool Manufacturing Co.
Albert Pipe Supply Co., Inc.
Alcoa, Rome Cable Division
Allis-Chalmers
Alpha-Molykote Corp.
Aluminum Company of America, Chemicals
Aluminum Company of America, Process Industries
American Air Liquide, Engineering & Construction Division
American Brass Company
American Bridge Division, United States Steel
American Chain & Cable Co., Inc., R-P & C Valve Division
American Machine and Metals, Inc., U.S. Gauge Div.
American Recording Chart Co.
Anaconda Metal Hose Division, American Brass Co.
Anchor Packing Co.
Anderson, K. W. Co.
Anderson, V. D. Co., Division of International Basic Economy Corp.
Anemostat Corp. of America
Anthes-Imperial Co. Limited, Penberthy Injector Ltd. Div.
Armour Industrial Chemical Co., Div. of Armour and Co.
Armstrong Machine Works
Arrowhead Iron Works, Inc.
ASA Refinery Piping Code
Ashmore, Benson, Pease & Co., Ltd.
Audley Engineering Company Limited
Aurora Pump Division, The New York Air Brake Co.
Autoclave Engineers, Inc.

Babcock & Wilcox Co.
Bailey Meter Co.
Baldwin-Ehret-Hill, Inc.
Barco Manufacturing Co.
Barrett Manufacturing Co.
Belmont Packing & Rubber Co.
Birwelco Limited
Blaw-Knox Co., Equipment Div. Power Piping Div. Buflovak Process Equipment
Borden Metal Products Co.
Borg-Warner Corp., Byron Jackson Pumps, Inc. Subsidiary
Born Engineering Co.
Brazzil Tool & Die Shop
Bridgeport Brass Co.
British Ermeto Corp. Ltd.
British Oxygen Gases Limited
Brown Fintube Co.
Buell Engineering Co., Inc.
Buffalo-Eclipse Corp., Penberthy Mfg. Co. Division
Byron Jackson Pumps, Inc., Subsidiary Borg-Warner Corp.

Calumet & Hecla, Inc., Wolverine Tube Division
Cambridge Wire Cloth Co.
Cameo Fittings, Inc.
Cameron Iron Works, Inc.
Cape Asbestos Co. Ltd.
Capitol Pipe & Steel Products, Inc.
Carey, Philip Mfg. Co.
Carlson, G. O., Inc.
Carpenter Steel Co., Alloy Tube Division
Carrier Corp.
Castle Hills Corp., Hartzell Propeller Fan Co. Division
Catawissa Valve and Fittings Co.
Causeway Reinforcement Ltd.
Cement Gun Company Ltd.
Chain Belt Co.
Chemetron Corp., Tube Turns Division
Chemical & Insulating Co. Ltd.
Chemical Construction Corp.
Chemineer, Inc.
Chicago Pneumatic Tool Co.
Chicago-Wilcox Mfg. Co.
Chiksan Co., Subsidiary of Food Machinery and Chemical Corp.
Childers Manufacturing Co.
Chisholm-Moore Hoist Division, Columbus McKinnon Chain Corp.
Clark Bros. Co., One of The Dresser Industries
Cleveland Wire Cloth & Mfg. Co.
Clyde Tube Forgings Ltd.
Coffin Turbo Pumps, Food Machinery and Chemical Corp.
Coffing Hoist Division, Duff-Norton Co.
Colorado Oil and Gas Corp., Marsh Instrument Division
Columbus McKinnon Chain Corp., Chisholm-Moore Hoist Division
Commercial Iron Works
Continental Boiler and Sheet Iron Works
Continental-Emsco Co., Swivel Joints Division
Cook Paint and Varnish Co.
Cooper Alloy Corp.
Cooper-Bessemer Corp.
Coppus Engineering Corp.
Cosasco Division, Grant Oil Tool Co.
Curtis-Wright Corp., Metals Processing Division

Davis Instruments
Dean Brothers Pumps, Inc.
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United States Stoneware Co.
Universal Atlas Cement Division, United States Steel

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REFINERY CATALOG

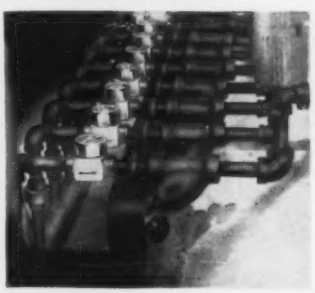
SARCO TOPICS

HOW TO SOLVE COMMON TRACER LINE PROBLEMS

How to cure water hammer with a steam trap that will operate in vertical position

Water hammer is an inherent problem in long tracer lines. So is freezing. Both problems can be overcome, and here's an example of how it has been done. At the Socony Mobil Oil Company's Paulsboro, N.J., refinery, they found that the Sarco Thermo-Dynamic Steam Trap, type TD-50, not only withstands water hammer, but installing the trap in a vertical position —which permits free drainage—presents no problems at all, thanks to its unique thermodynamic principle. In fact, 90% of the 250 TD-50's at this plant are vertically mounted. They never block heat transfer, and they remove condensate and air as fast as they collect.

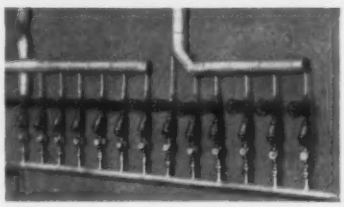
How to handle varied steam pressures — without adjustment



Can a trap — without adjustment — handle steam pressures that vary from 15 to 160 psi? Can the *same* trap vent air and drain condensate as rapidly as it is formed, be easy to install and require practically no maintenance at all? That was the problem set up by the engineering staff of Armour Chemical Division's McCook plant. They solved it by testing many traps. Their conclusion: Sarco TD-50 steam traps meet or beat their specifications, because:
they discharged condensate as fast as it formed, without wasting steam;
their compact inline construction made installation easy, even in tight quarters;
maintenance was practically negligible;
no adjustment was necessary for varying steam pressures. (In fact, the TD-50 is self-adjusting through its full operating range of 10-600 psi.)

No other steam trap can so adequately solve all these problems at one time.

How to be certain process fluid stays above 280° F. in tracer lines when outside temperature drops to – 10° F.



The problem of maintaining design temperatures on tracer lines need not be difficult, no matter how extreme the conditions seem to be. For example, the tracer lines in a phthalic anhydride process at Witco Chemical Company's new Chicago plant had to be maintained above 280° F. Below this temperature, the chemical sets and the whole system would have to be taken apart and re-assembled. That's not all; ambient temperatures sometimes could drop to −10° F.

With reliability as a prime consideration, Scientific Design Company, Inc., who designed and constructed this brand new plant, selected the TD-50.

Because the TD-50 can be mounted vertically, freezing was no problem either. Added benefits that matter on tracer lines: the TD-50 is compact, light in weight, easy to install.

What is the most reliable tracer line trapping method to prevent unscheduled shutdown?

Particularly in refineries, steam traps have to function under exactly the kind of conditions that you'd expect to cause failure—they must function equally satisfactorily on low pressure or exhaust steam and on up through high-pressure, high temperature ranges. Not only that, but outside temperature may vary from subzero to subtropical. If maintaining design temperatures in your tracer lines appears to be hampered by these problems, consider how Phillips Petroleum Company, Kansas City, solved them. They found a trap which drains their tracer lines automatically over a full range of pressure, temperatures and loads. It's the Sarco TD-50 Steam Trap.

With only one moving part—a stainless steel disc, the TD-50 has little that can go wrong. In fact, it's so free of trouble that Phillips Petroleum Company consider their TD-50's as reliable and efficient as the piping. They now rely on 1800 of them throughout the plant. 1408

FOR FULL INFORMATION ON TRACER LINE TRAPPING or on any steam trapping problem—see your Sarco Sales Representative or write to

SARCO COMPANY, INC.
635 Madison Avenue,
New York 22, N. Y.
Plant: Bethlehem, Pa.

STEAM TRAPS • TEMPERATURE CONTROLLERS • STRAINERS • HEATING SPECIALTIES

SARCO

Here are 7 Sound Reasons Why the Thermo-Dynamic® Does a Better Job of Trapping

1. *Simplicity*—has only one moving part. 2. *Maintenance*—practically zero. 3. *Wide pressure range*—one trap for all pressures from 10 to 600 psi. 4. *Uniform performance*—operates equally well on heavy, light, or no condensate load. 5. *Operates against back pressures*—up to 50% of inlet pressure. 6. *Rugged*—unaffected by superheat, water hammer, vibration, or corrosive condensate. 7. *Minimizes inventory* of spare parts.

Maintenance Time: 40 Seconds. If it now takes your maintenance crew more than a couple of minutes to service an ordinary trap, you're throwing away valuable time. This Sarco Thermo-Dynamic can be cleaned, blown out if necessary, and reassembled on the line in as little as 40 seconds.

For Prompt Information on the TD-50 . . . or for fast help on the efficient solution of any steam trapping problems, get in touch with a SARCO District Office, Sales Representative, or Distributor. (There's one near you.)

Only SARCO makes all 5 types:

Thermo-Dynamic* • Thermostatic • Liquid Expansion • Float Thermostatic • Inverted Bucket

*U.S. Pat. No. 2,817,353 TM Reg. U.S. Pat. Off. 1409

SARCO COMPANY, INC.
635 Madison Ave., New York 22, N. Y.

Equipment . . .

for disintegration, mixing and agglomeration; vibrating and gyratory screens for dry separation; blade mills, pool washing screens and log washers for liquid separation; kilns, dryers, slakers, pelletizers, coolers, and liquid heaters for heat transfer.

The guide also covers electrical equipment for the complete process plant, electronic metal detectors, water conditioning equipment, chemicals and service, car shakers, lift trucks, tractors, etc. Allis-Chalmers Mfg. Co.

Circle E21 green card, last page

Balanced Boom Cuts Truck Loading Time

A major New England marketer recently installed a 6 inch spring-balanced boom-type loading arm assembly. This major oil company planned to eventually be able to deliver through 6-inch equipment and it had installed 6-inch meters and piping at its loading racks of recent construction. A 50-HP, 2,700-gpm pump now supplies 1,320 gpm of No. 2 oil, with 45 to 50 psi. A specially designed loading valve eliminates dangerous shock and shuts off at 1.7 seconds with only 35 gallons of afterflow.

The operators say it is as easy to handle this unit as 4-inch equipment, and loading time has been cut in half with the addition of this loading arm. Wheaton Brass Works.

Circle E22 green card, last page

New Catalog-Data Book On Oil Storage-Handling

A 100-page catalog, engineering-data book on a complete line of oil storage, loading and handling equipment is available.

The plastic-bound data book is sectionalized with indexing tabs for quick reference on the manufacturer's line of storage tank fittings, gauges, strainers, and valves. It also includes information on swing joints. Emco Brass Mfg. Co., Ltd.

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16-Page Bulletin Covers Condenser Design Details

The design and construction of Type F surface condensers are described and illustrated with shop and installation photographs. Sectional drawings and photos supplement descriptions of associated process equipment and accessories —steam-jet ejectors, duplex drainers, and the air-leakage meter. Tables, a curve, and a complete example show how to check condenser performance. Elliott Co.

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Pneumatic Controls For Hazardous Locations

A four-page booklet on explosion-proof controls, indicating, non-indicating and recording, has just been prepared.

In addition to electrical explosion-proof controls, the manufacturer also offers pneumatic controls in both indicating and recording models for hazardous locations. They incorporate as electrical controls all the basic company design features, which, according to the booklet are:

- Direct, positive mercury actuation, which eliminates the need for outside amplification;
- Extreme sensitivity, up to ½ percent of scale range;
- High accuracy, up to 1 percent of scale range. Partlow Corp.

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Bulletin Describes System Telemetering Remote Data

A new Pulse Code Telemetering System Bulletin has been published which describes and illustrates several types of applications of a system for the remote indication of liquid level, temperature, PD meters, pressure gauges, control device indicators, data gathering and reduction, and alarm and control functions. The Vapor Recovery Systems Co.

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61	62	63	64	65	66—67		68	70a	70b	70c	71—72	73	74	75	76—77	78	79		
80—81	82	83	84—85	86	87	88—89	90	91	92—93	94	95	96—97	98	99					
100—101	102	103	104	171	173	174	175	176	179	180	181	182a	182b	183	184	189	193	197	
199	202	203	204—205	207	208—209		210	211	212	213	214	215	216	217	218	219	220	221	
223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238a	238b	240—241	242	
243	244a	244b	245	246	247	249	250—251		253	254	255a	255b	256a	256b	257	258	259	260	261
262—263	263	264	265	266	267	268—269		270	271	272a	272b	273	274—275		276—277		281	282	

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223	224	225	226	227	228	229	230	231	232	233	234	235	236	237	238a	238b	240—241	242
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262—263	263	264	265	266	267	268—269	270	271	272a	272b	273	274—275	276—277	281	282			

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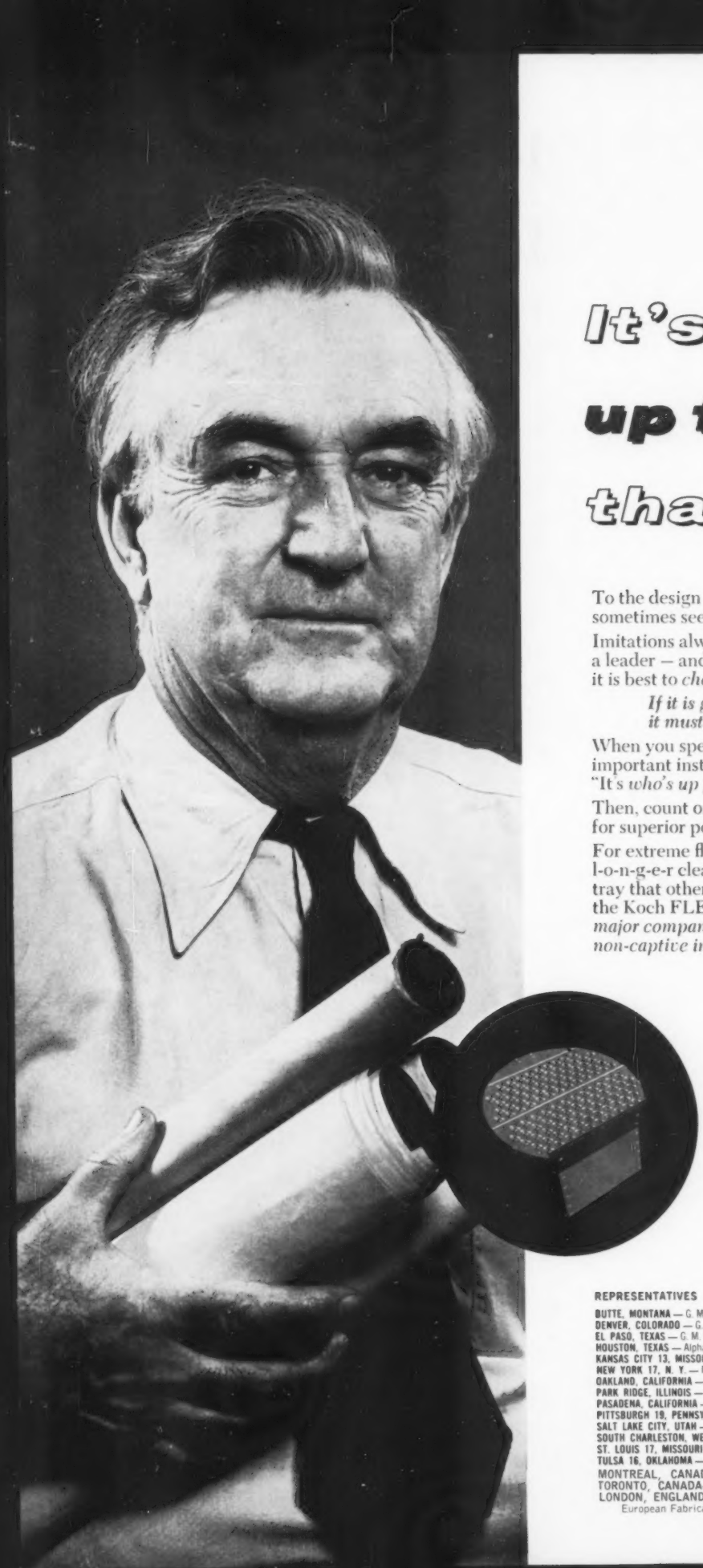

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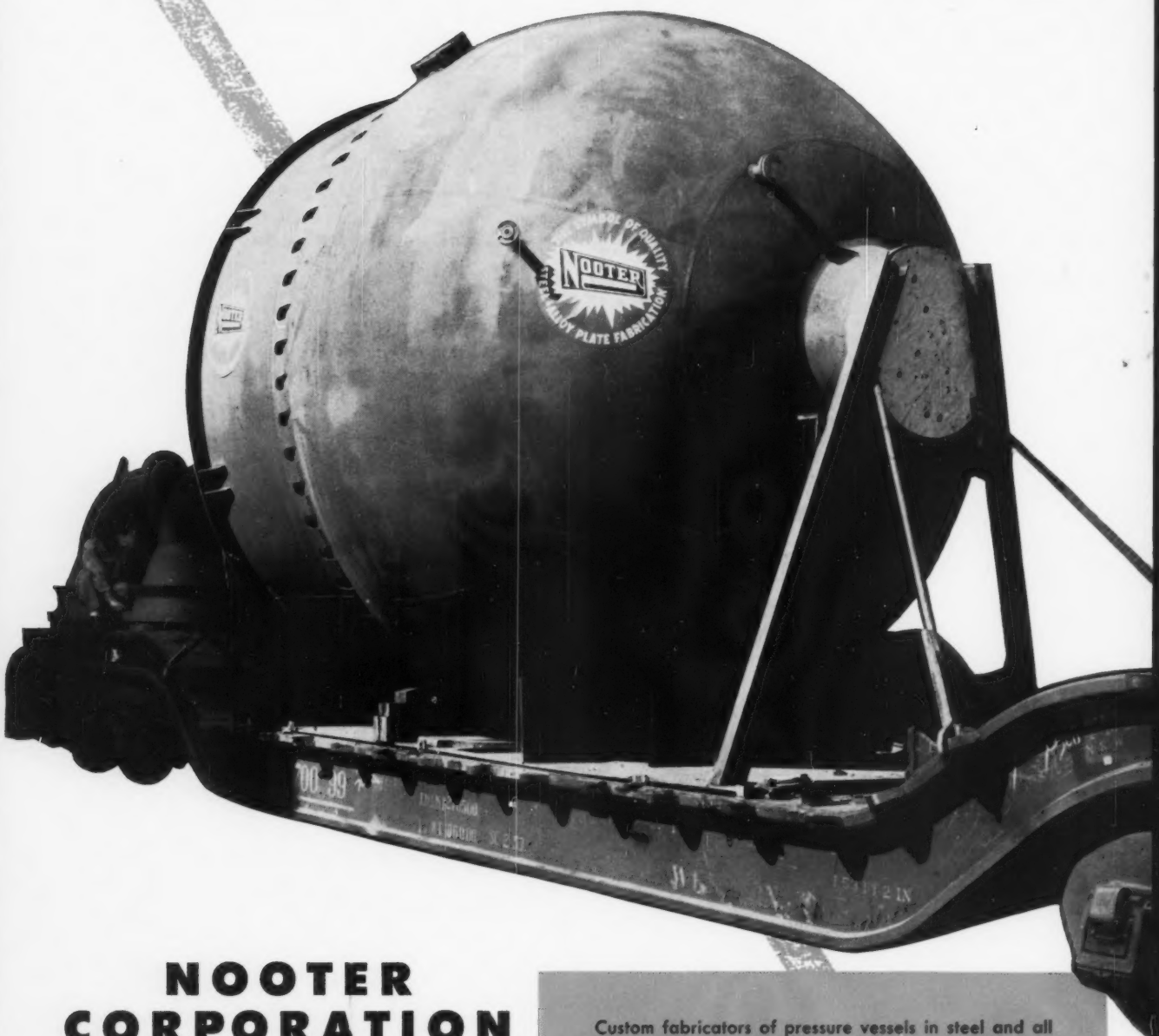

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